The coastal realm: managing marine resources, biodiversity and ecosystems in a rapidly changing world

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joint work with: Nova Mieszkowska, Martin Genner, Elvira Poloczanska, Mike Burrows and ALAN SOUTHWARD

Pippa Moore, Mike Kendall, Stuart Jenkins, Rebecca Leaper, F. Pannaccuilli, Louise Firth, Georgina Budd, Patricia Masterson, Richard Thompson, David Sims, Paula Moschella, Keith Hiscock, and many others

Outline of talk

(Scene setting and relevant to sub themes 1, 4 & 5 of the draft thematic report)

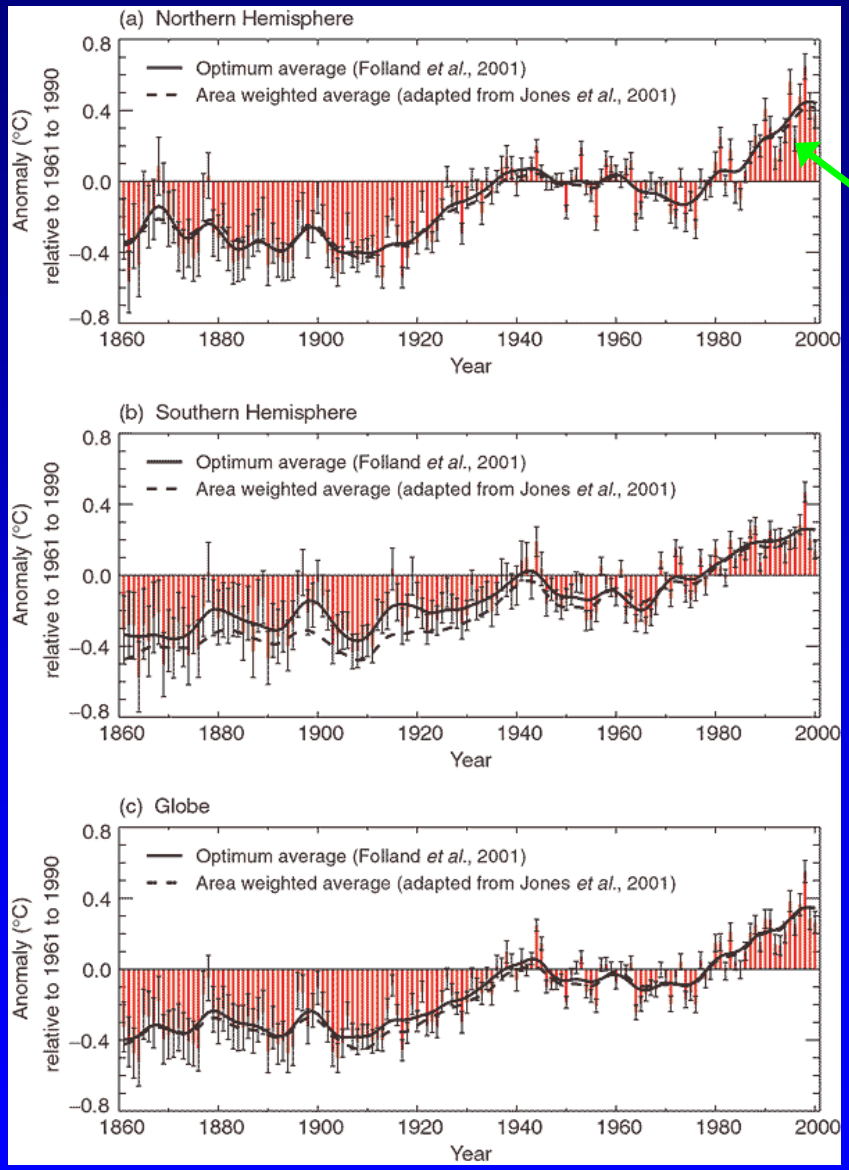
- Background on climate change in North East Atlantic
- Interactions of climate change with other impacts at global, regional and local scales on coasts and in nearshore areas– particularly fishing
- Rocky shore indicators: broad-scale re-surveys and time series restart
- Functional consequences of change in coastal systems
- Policy implications – adapting to climate change whilst managing natural resources

Plea for maintenance of long term data sets and their networking…essential for management of the Atlantic

Adaptation: manage interactions between global climate-driven change and regional and local scale impacts

- Non-native species (global climate change interacting with global biogeographic homogenisation)
- Fishing pressure and climate change (global & regional)
- Eutrophication, pollution and climate change (regional and local scale)
- Coastal development and climate change (local scaling up to regional scale)

Climate Change in the N.E. Atlantic

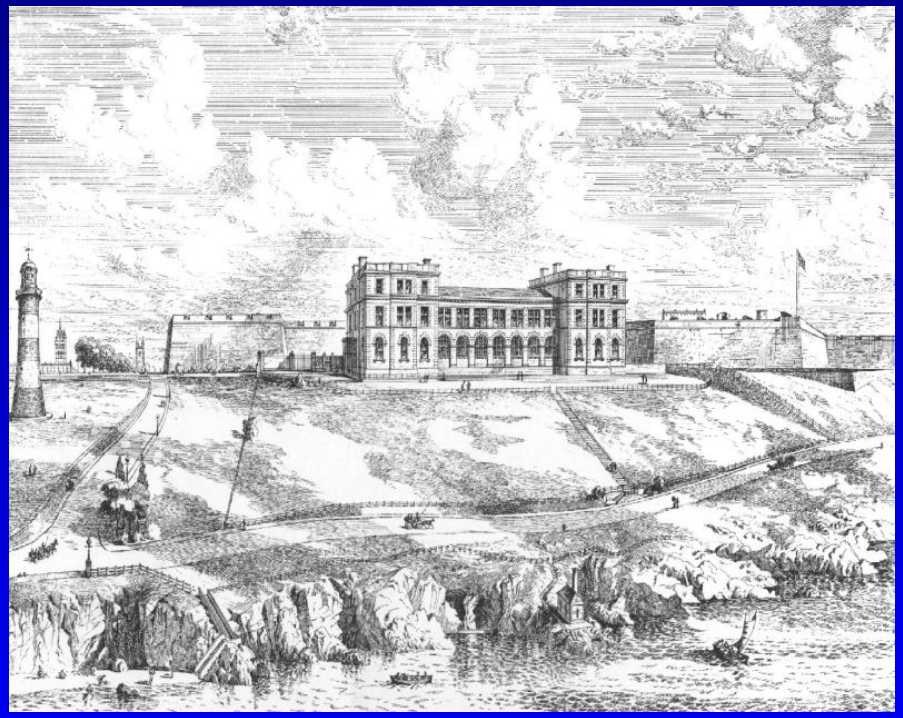


IPCC Climate Change 2001 The Scientific Basis

Particularly strong warming has occurred in the North Atlantic since the mid-1980s (35° to 65°N, 0° to 35°W)

This is 2 x rate of any previous warming event on record, 0.5-1°C in last 20 years

← Exceeds global average



THE MARINE BIOLOGICAL ASSOCIATION

MBA Time Series: English Channel

Western Channel Observatory from 2007 PML/ MBA/SAHFOS

Temperature and Salinity	E1	1902-1987, 2002-
Nutrients	E1	1921-1987, 2002-
Phytoplankton	E1	1903-1987, 2002-
Primary production	E1	1964-1984
Zooplankton	E1, L5	1903-1987, 1995-1998,2002-
Planktonic larval fish	E1, L5	1924-1987, 1995-1998,2002-
Demersal fish	L4	1913-1986, 2001-2003,2005-
Intertidal organisms	various	1950-1998, 1997/2001-2005,-
Infaunal benthos (intermittent)	L4	1922-1950, 2003
Epifaunal benthos (intermittent)	L4	1899-1986, 2005-

PML time series:plankton & hydrography at L4 since 1987

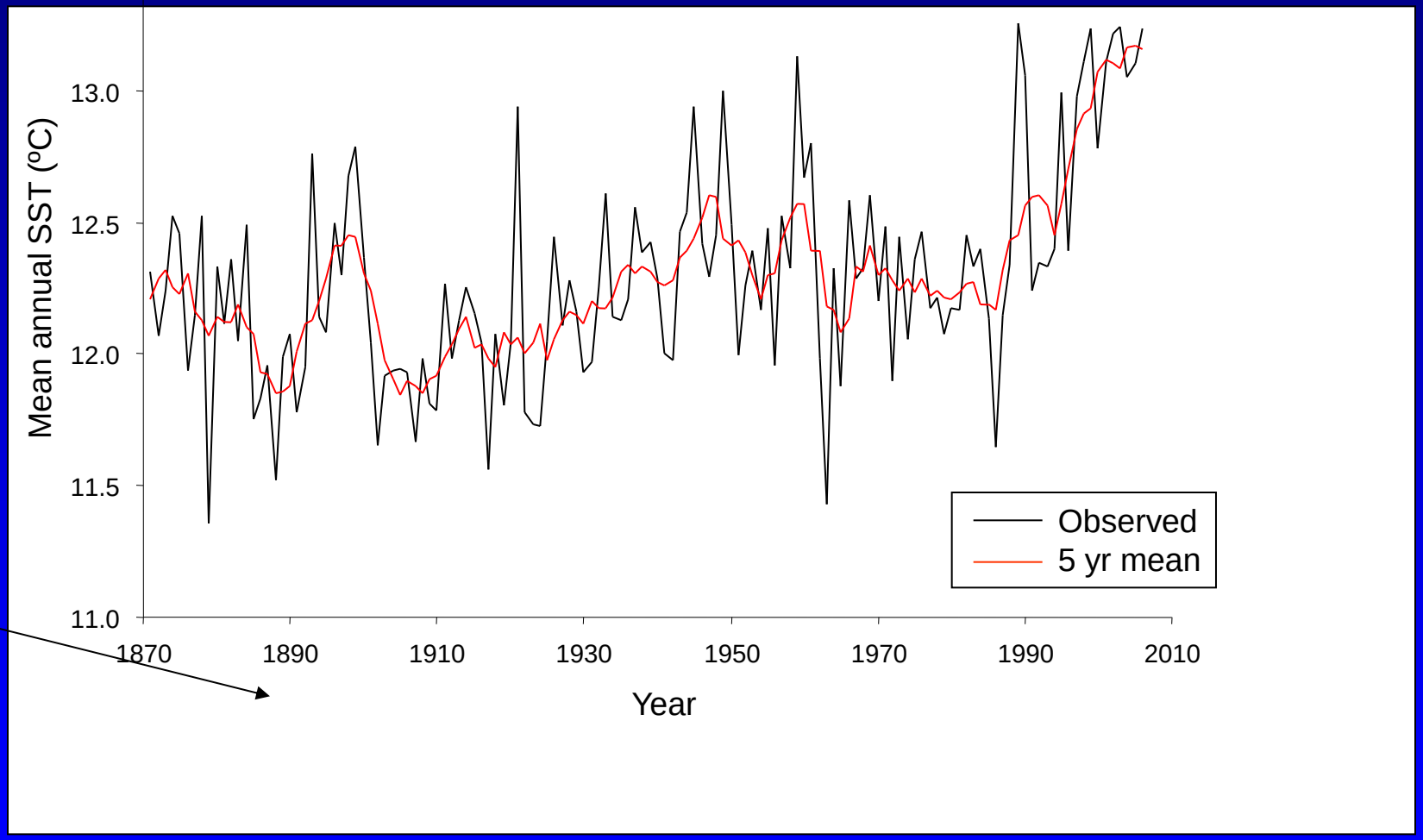
n.b. There are many gaps in these series,

Defra & Agg. levy funded restarts in red

Reviewed in Southward et al., Adv. Mar. Biol. 47:1-105, 2005

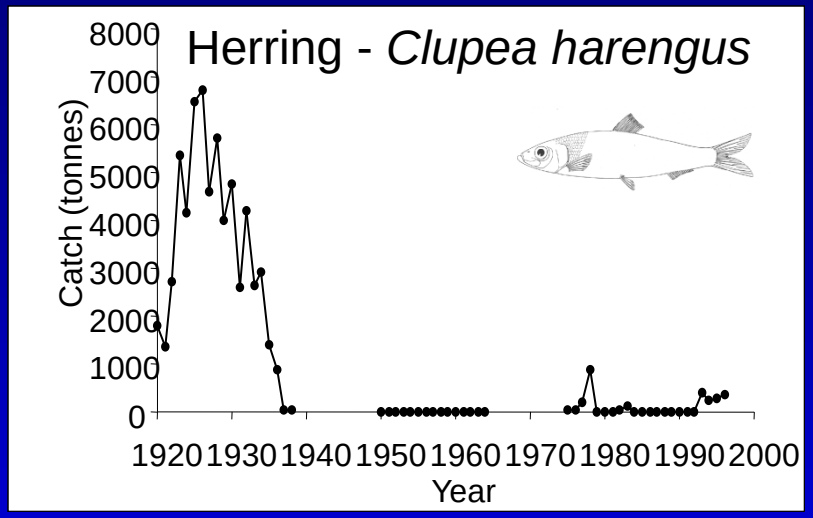
Mean annual sea surface temperature 1871-2006 off Plymouth

(grid square 50–51° N, 04–05° W).



Data from the UK Meteorological Office Hadley Centre. Much of it collected by the MBA/PML

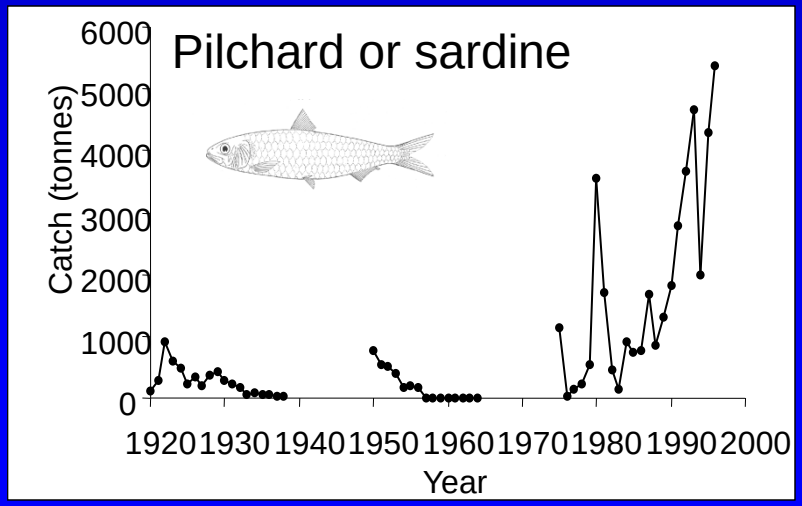
Landings of pelagic fish at Plymouth



Sutton Harbour, 1925

Such fluctuations occur back to the middle-ages

(Southward et al. 1988 JMBA 68(3): 423-445)

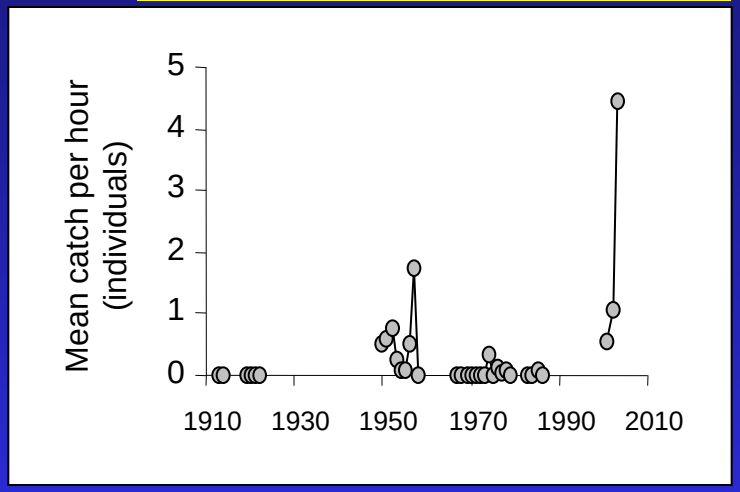


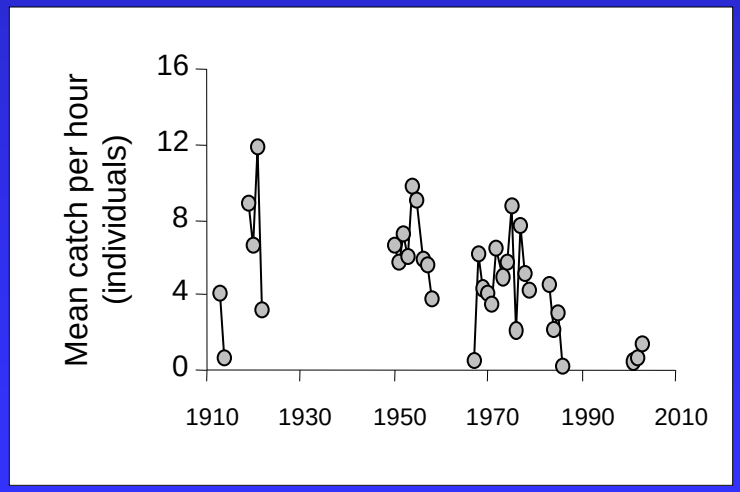
Data source: UK Government records

Interaction of fishing and climate

Plymouth inshore demersal fisheries

Climate change





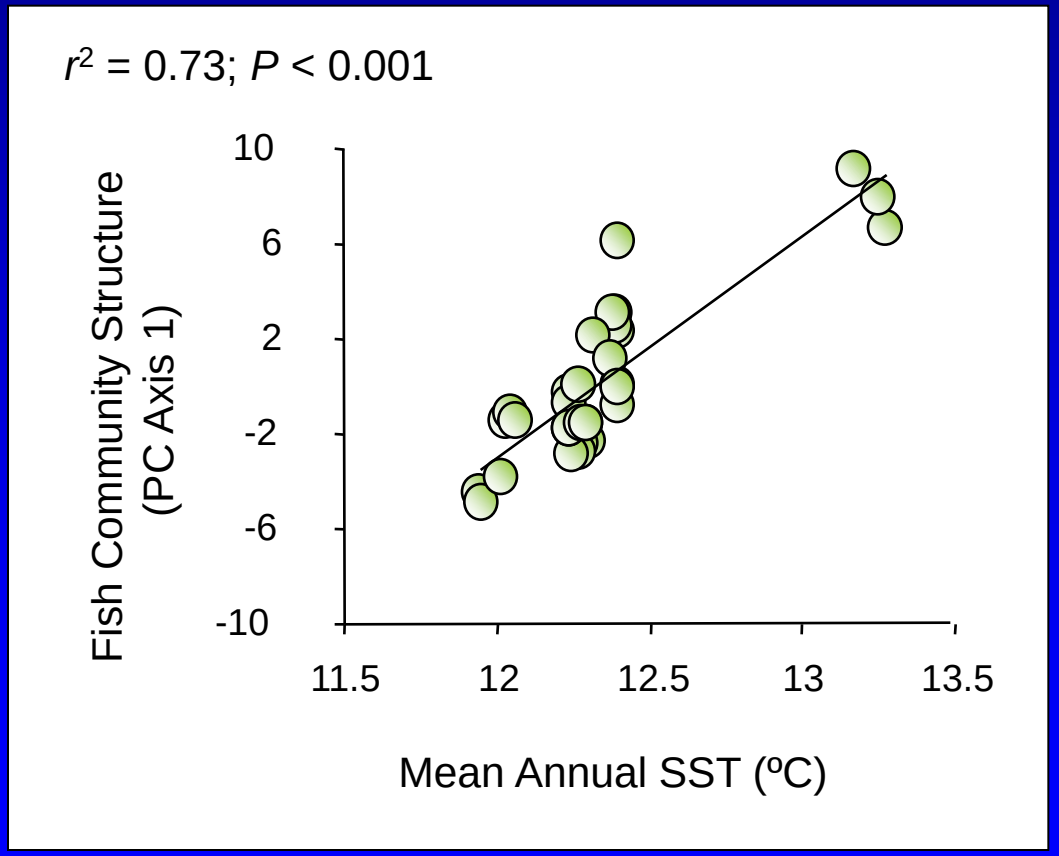
Fishing pressure

Breams (Family Sparidae)

Rays (Family Rajidae)

Genner et al., unpublished

PC1, an index of community-level change, correlates with sea temperature



Genner *et al.* (2004) *Proc. R. Soc. London B 271:* 655-661

MBA Trawls: fewer large fish species in catches due to fishing

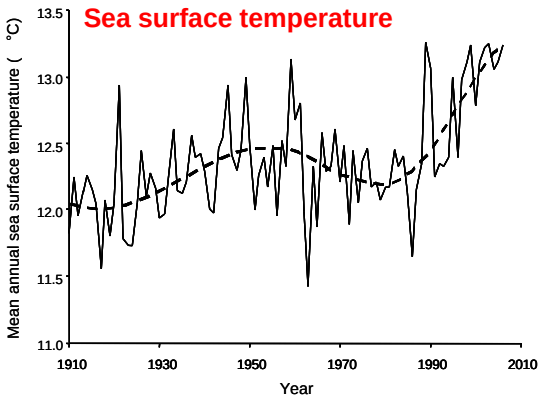
October 1963

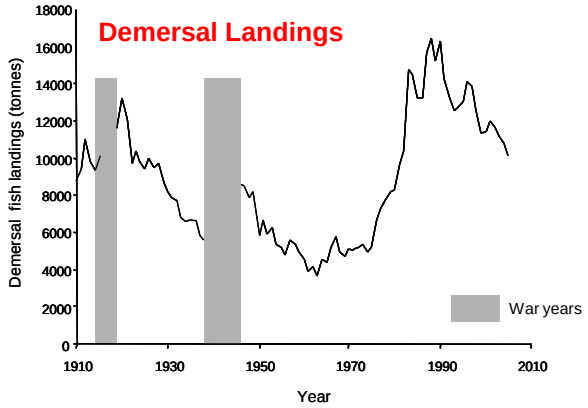
November 2001

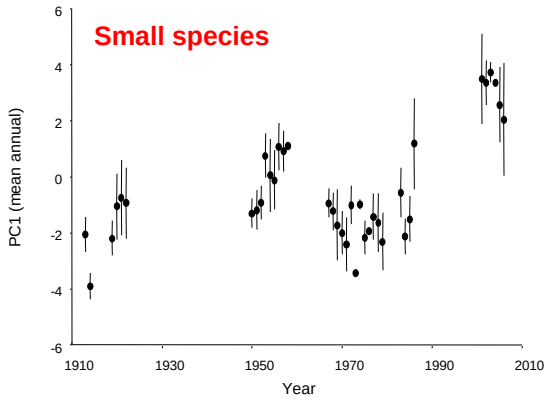
August 2006

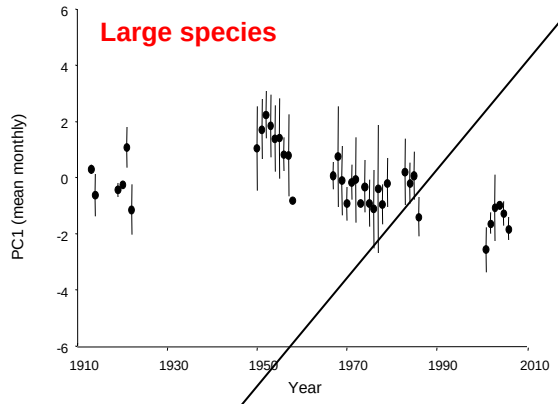
Sharpest declines seen in large species: skate & ray, brill, conger eel

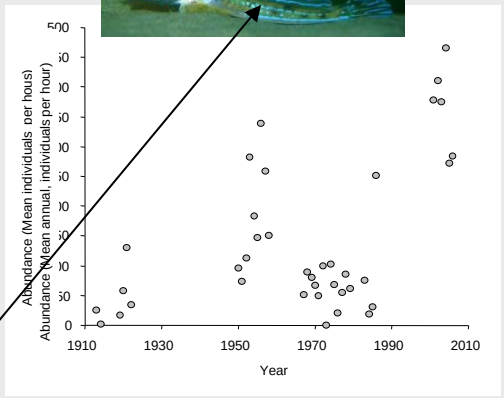
English Channel fish assemblages

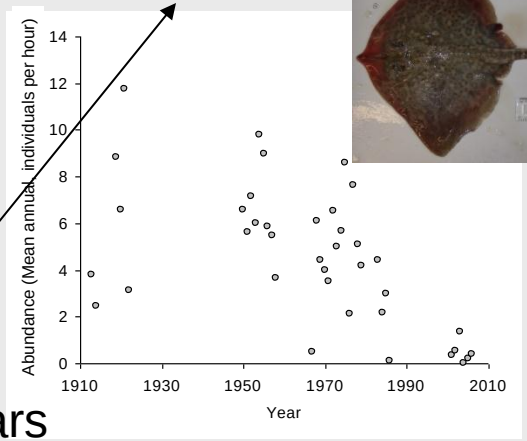












Small species – follow climate change

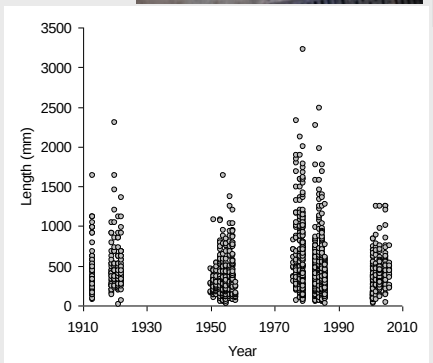
Large species - abundance declines over the last 50 years

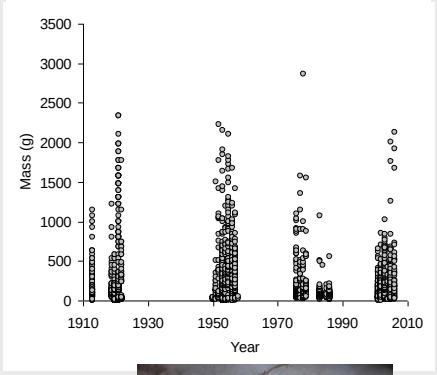
Co-funded by DEFRA (projects MF0727 and MF0730; 2000-2003)
Genner et al GCB (2011)

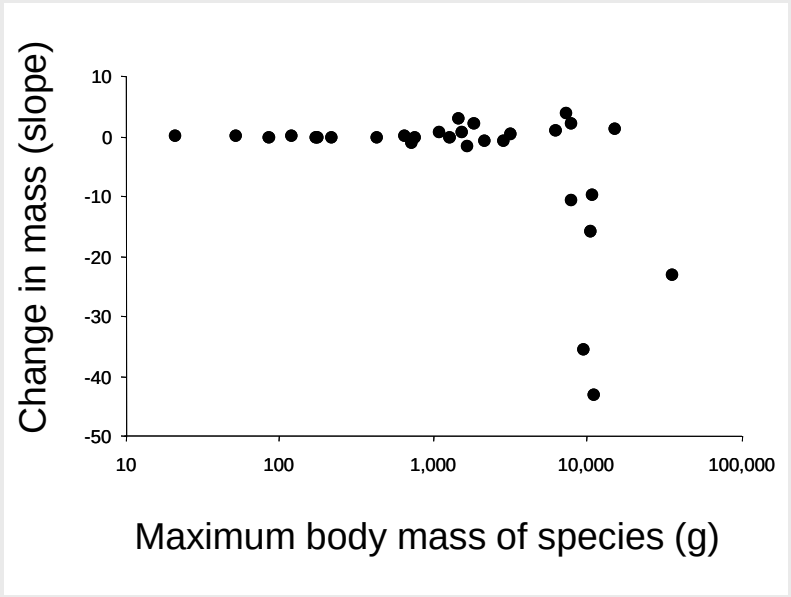
English Channel fish sizes 1913-2006

Plaice

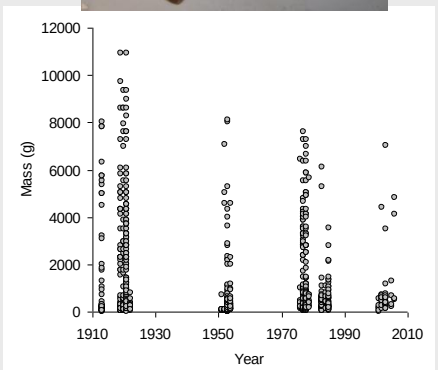
Small and medium species – no change
Large species – fewer large individuals

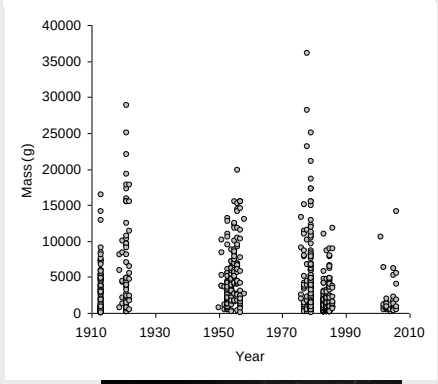






Rays





John Dory

Monkfish

Genner et al GCB (2011)

Fish populations in the English Channel

- Massive changes in assemblage composition
- Interaction of climate & fishing driving changes in bottomfish
- Climate influenced advance of southern species; northern persisters?
- Good evidence of climatic impacts on pelagic species : Herring-pilchard(sardine) switches back to 13th century (Southward et al. 1998 JMBA)

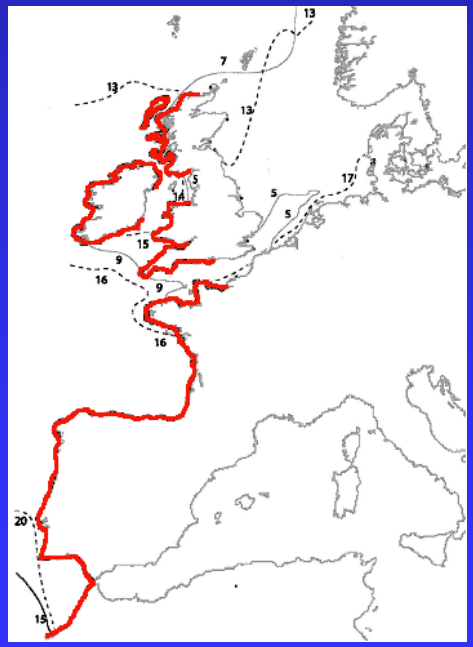
SHIFTS IN RANGE and CHANGES IN ABUNDANCE ON ROCKY SHORES

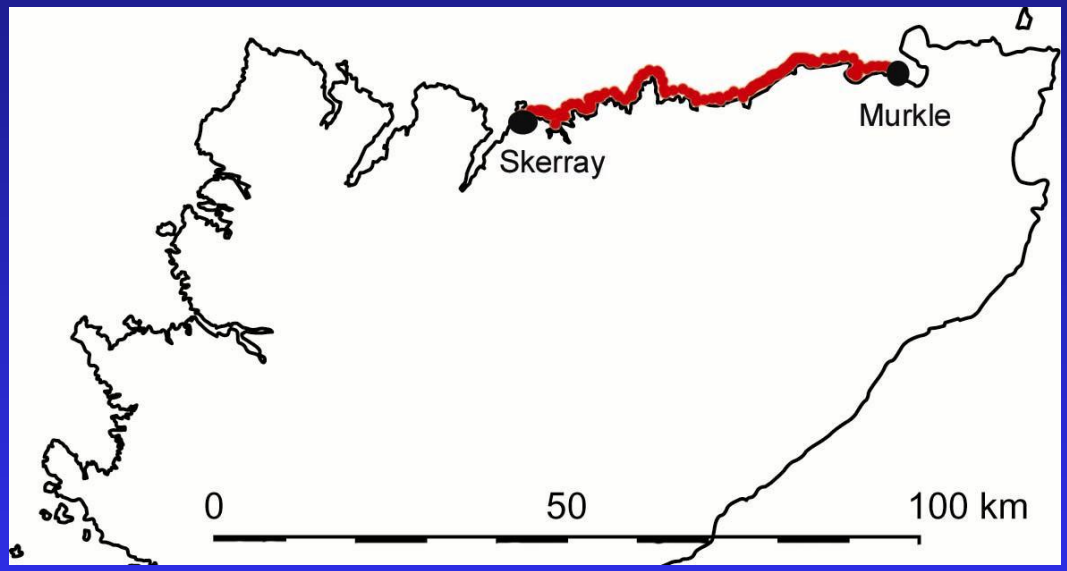
Hawkins et al 2009 MEPS

Intertidal organisms - inexpensive indicators of change in nearshore ecosystems (UK –Irish Marclim project)

- Easily sampled non-destructively on broad-scale
- Amenable to mapping and hierarchical statistical approaches
- Processes understood from experimental ecology
- Larval success in offshore environment reflected in recruitment
- Good time-series availability (N & S pairs of spp)
- Not exploited much (at least in UK and Ireland)

Example of changes in the distribution of a intertidal species in Northern Scotland (spring 2002)

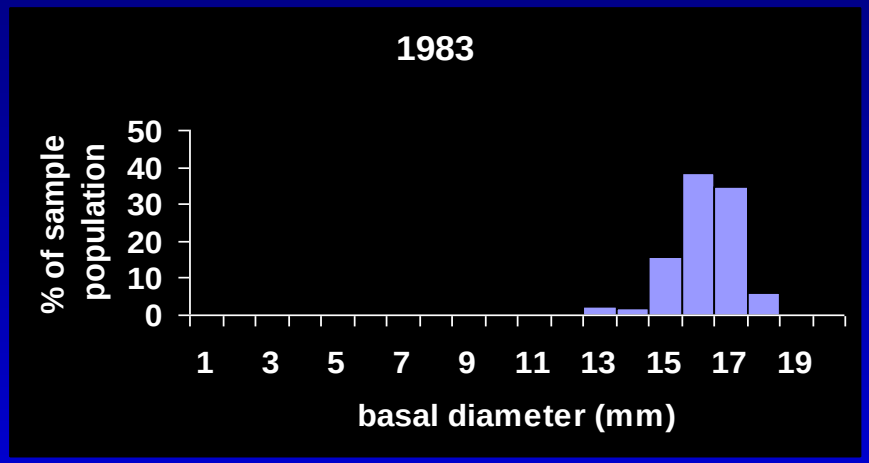




- **northern range extension of ~70km in North Scotland since 1986 (Miezskowska, unpub)**

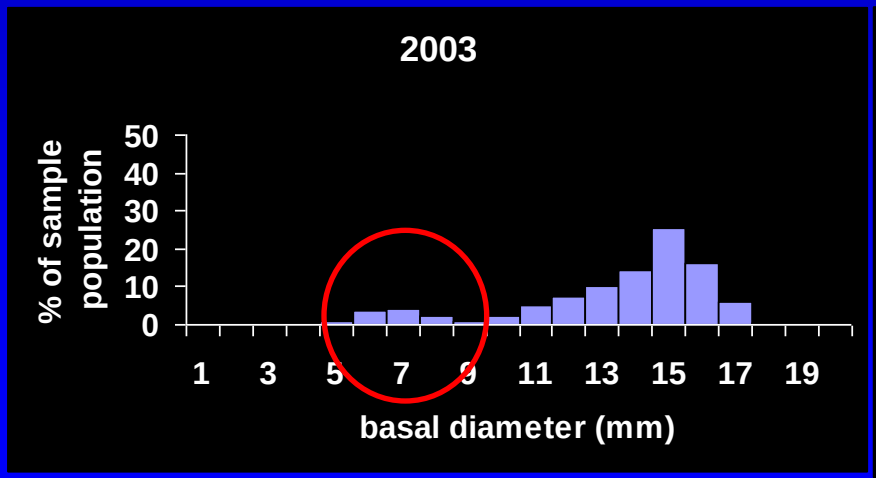
Top shell – *Gibbula umbilicalis*

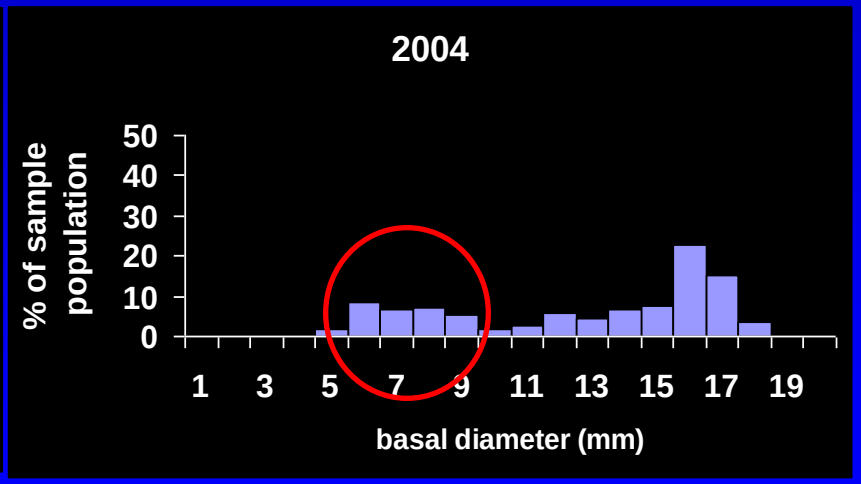
Changes in population dynamics near northern range edge



Frequent recruitment failure in cooler 1980s

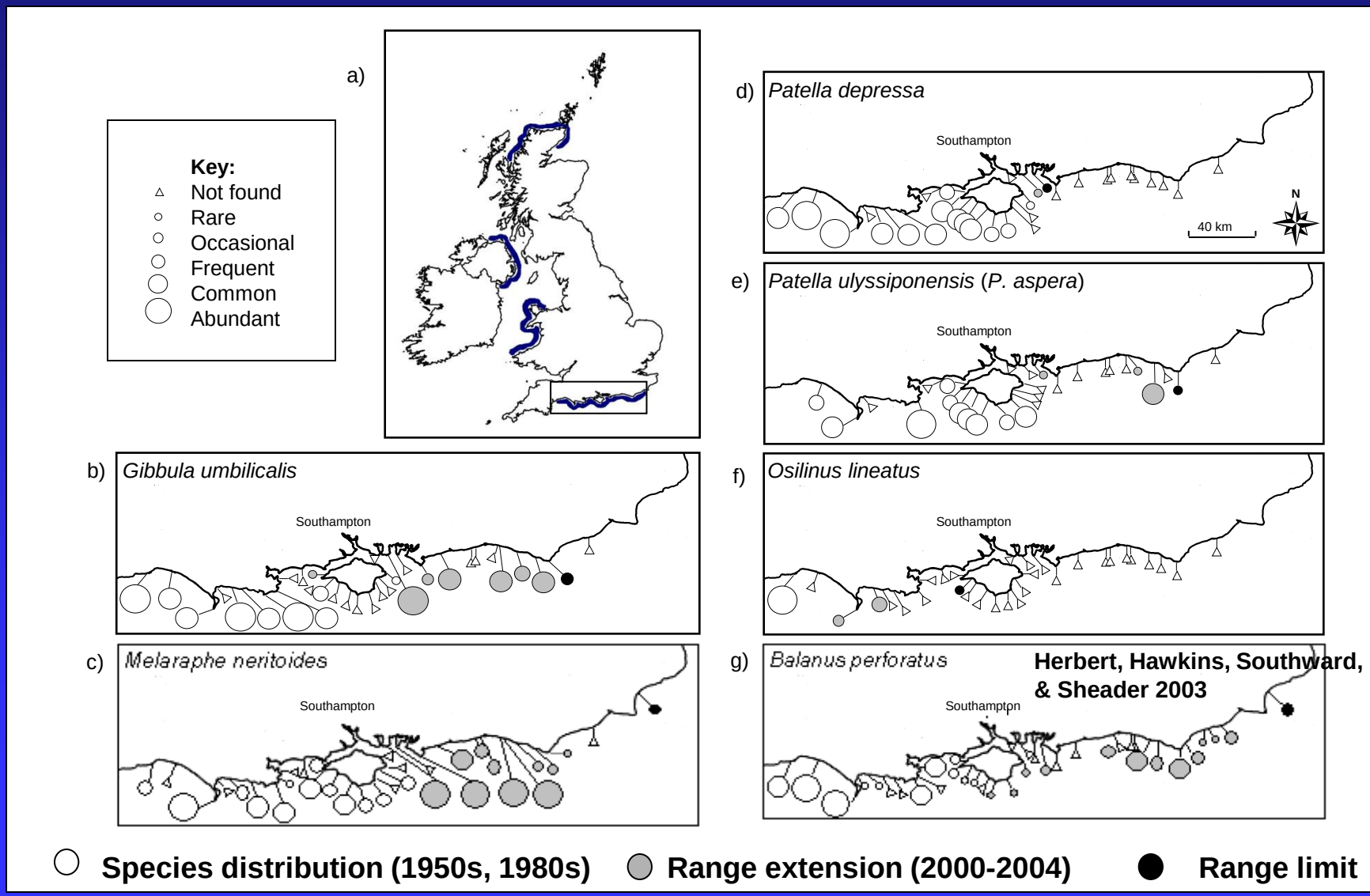
Successful recruitment every year in warmer 2000s





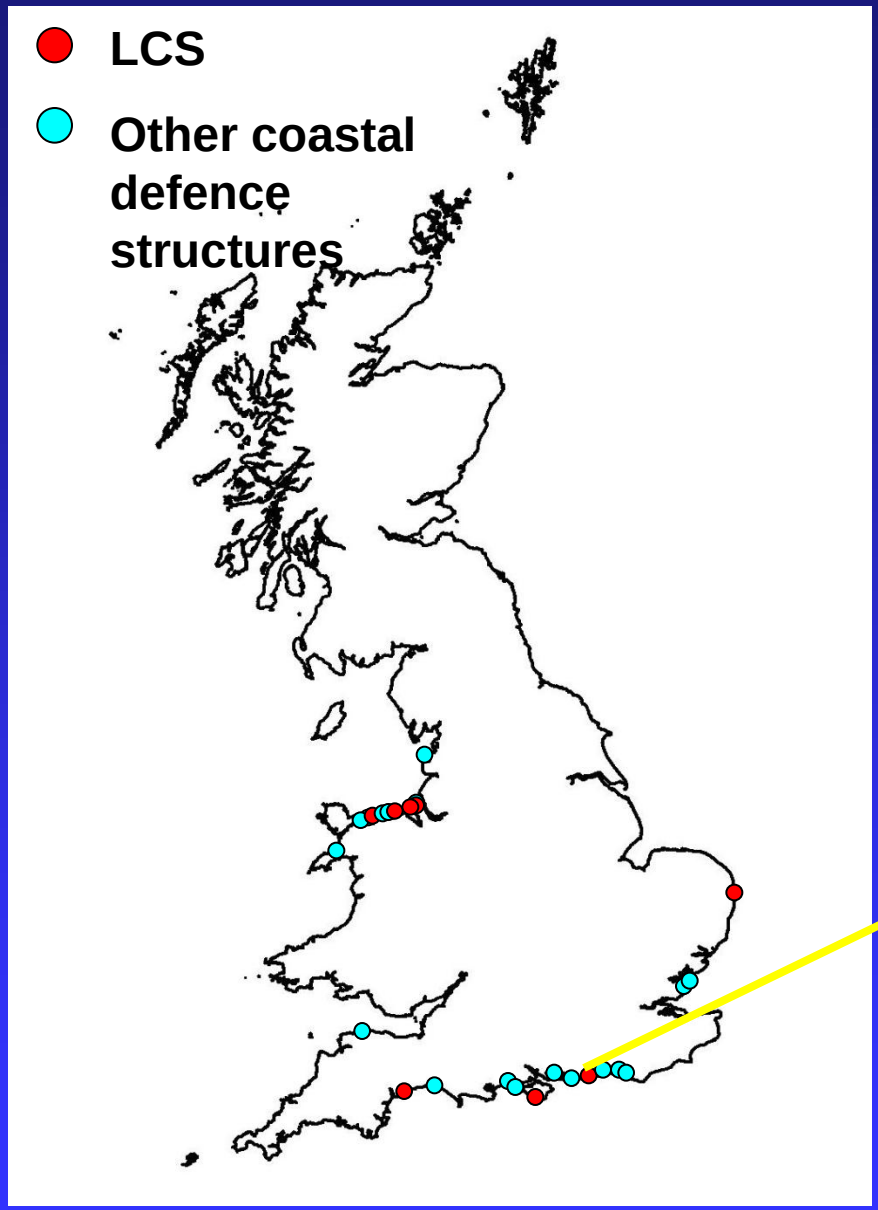
Mieszkowska et al. *G. umbilicalis* at Culkein, N. Scotland

Range edge distribution of intertidal species in the English Channel (summer 2004-2005)



Hawkins, Mieszkowska, Moschella new data, 2004-2005

Broad-scale modification of coastline



Elmer defence scheme

Range extensions of southern species

Gibbula umbilicalis

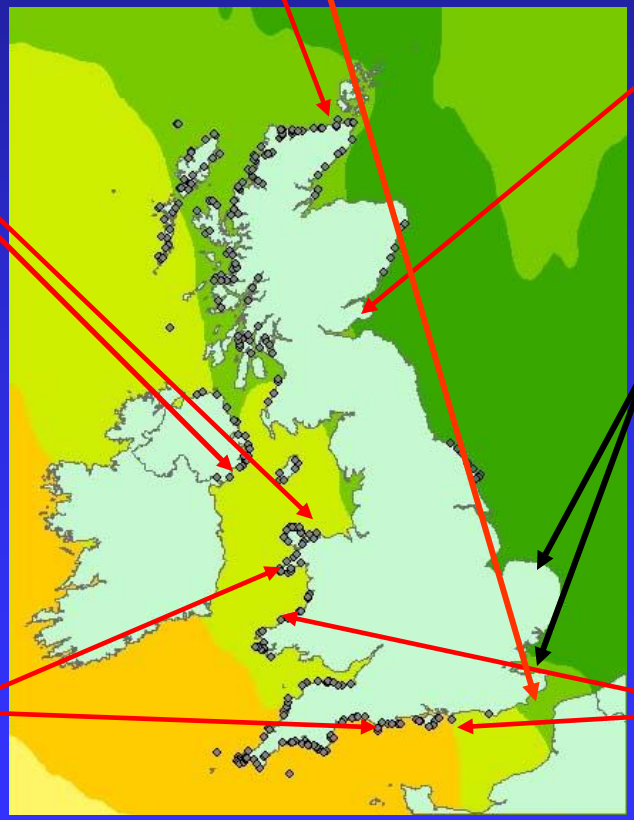
Purple topshell

Osilinus lineatus

Toothed topshell

Chthamalus montagui

Stellate barnacle



Melaraphe neritoides

Small periwinkle

Bifurcaria bifurcata

Brown alga

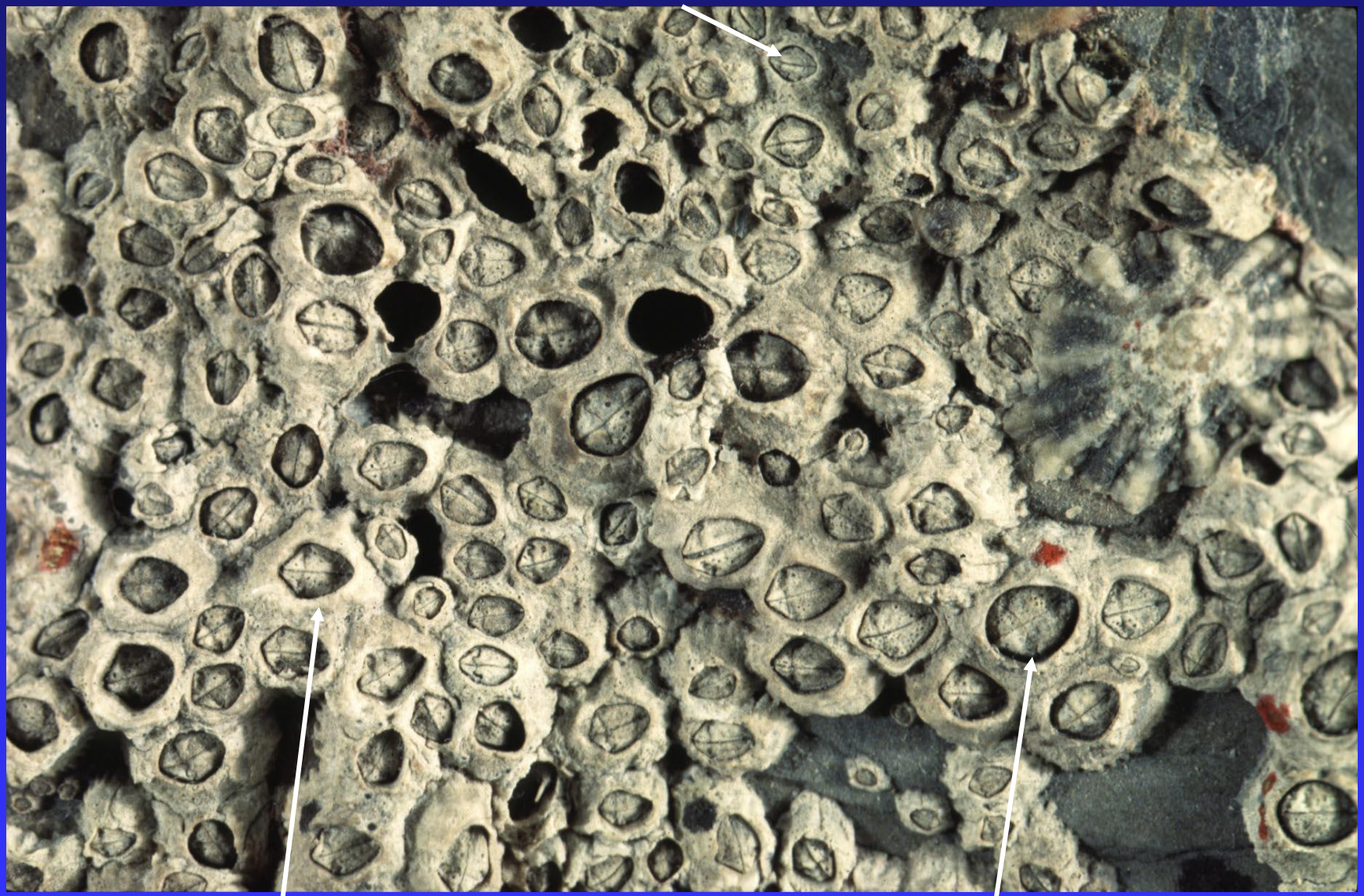
Balanus perforatus

Acorn barnacle

Modelling using barnacles

- Predictive modelling of interacting species
- Statistical analysis of past data sets
- Process-based modelling including indirect effects
- Forecasts using scenarios

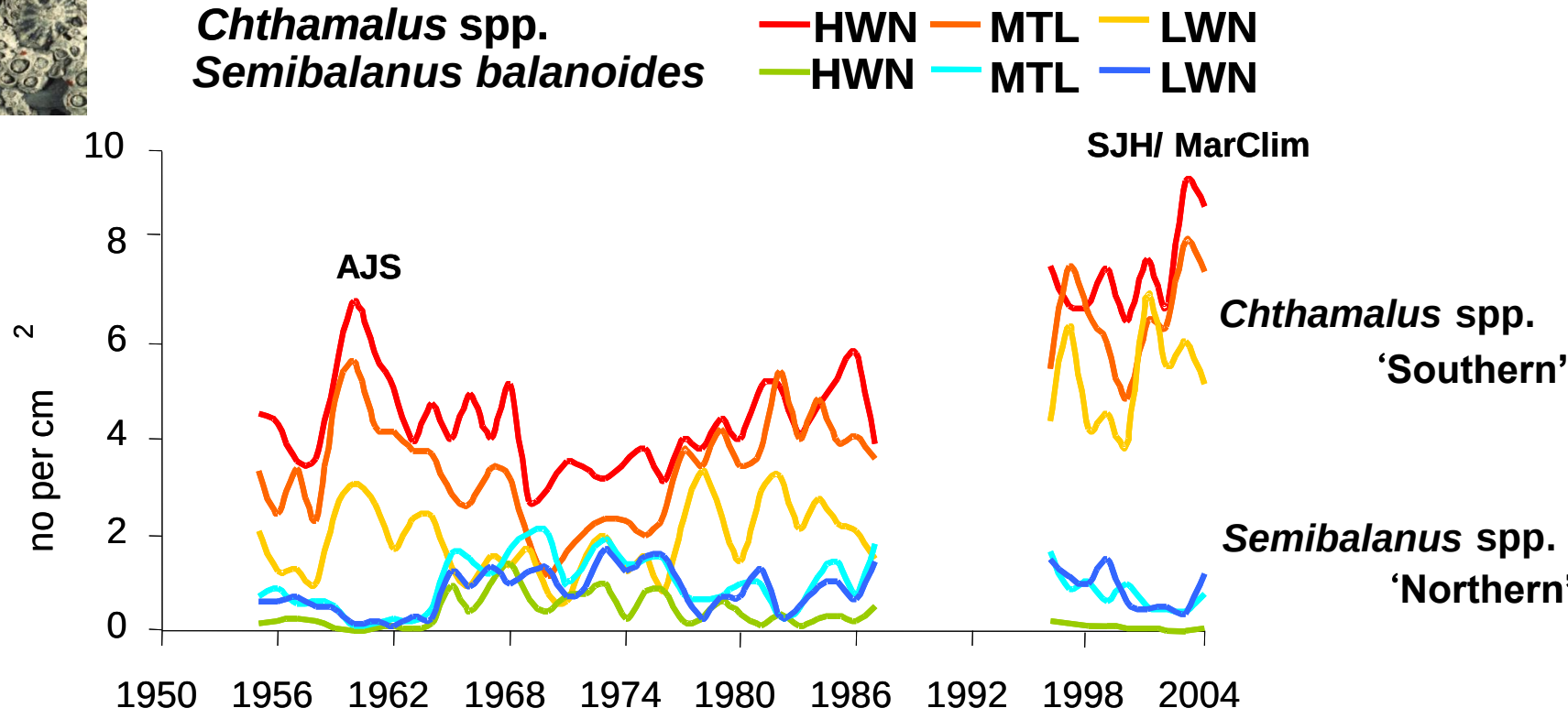
Semibalanus balanoides (northern species)



Chthamalus montagui *Chthamalus stellatus*

(southern species)

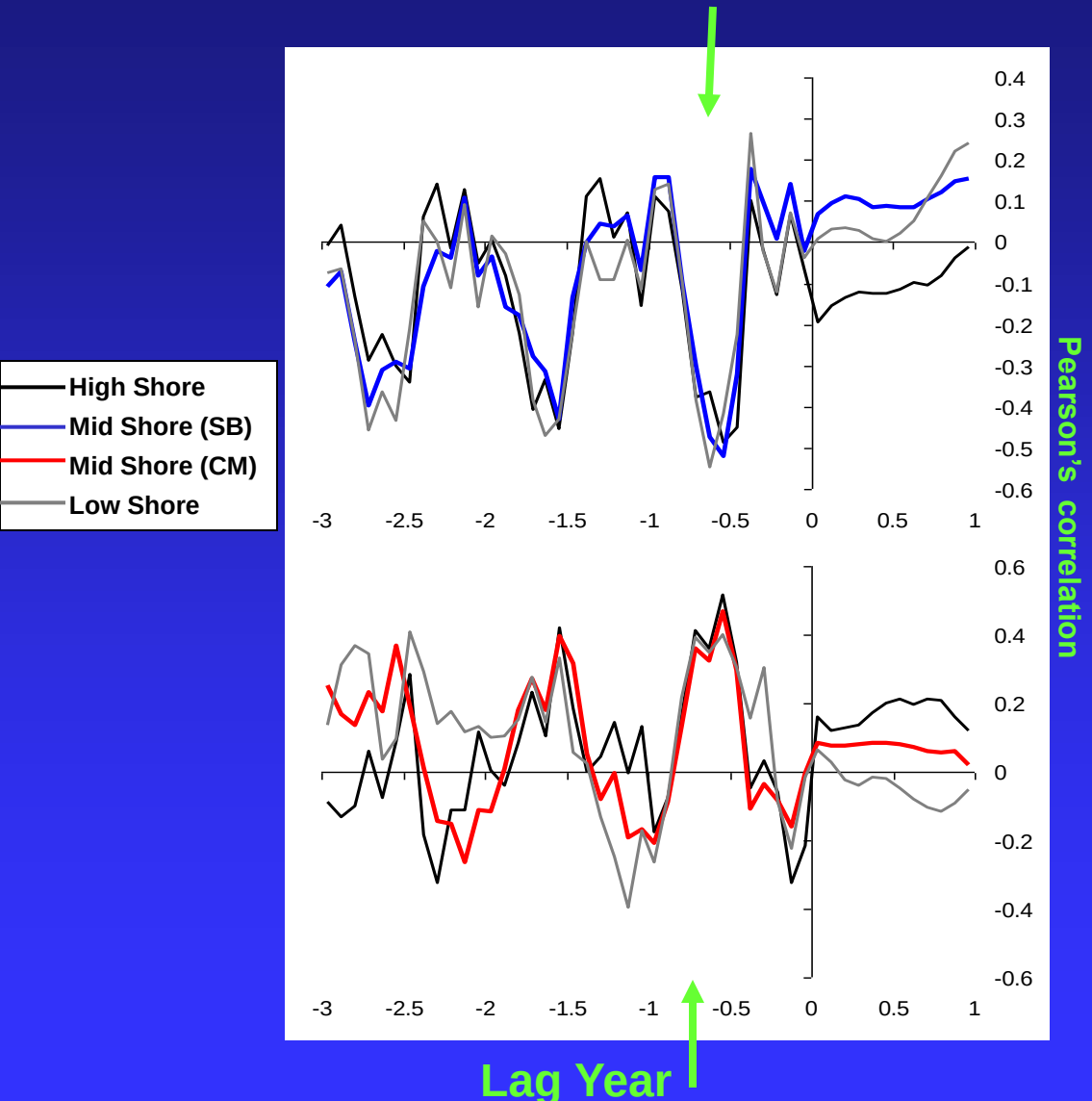
MBA time series: abundance of barnacles in S.W. England (8 sites south coast)



1997-2003 NERC small grant

Southward (1967, 1980, 1991) then Hawkins;

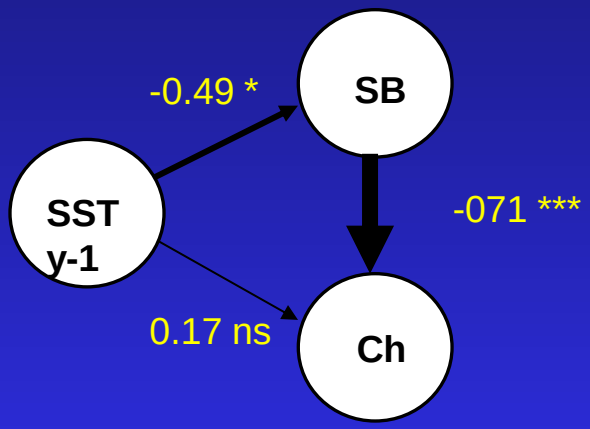
Correlation of adult abundance with monthly lagged sea surface temperature (SST)



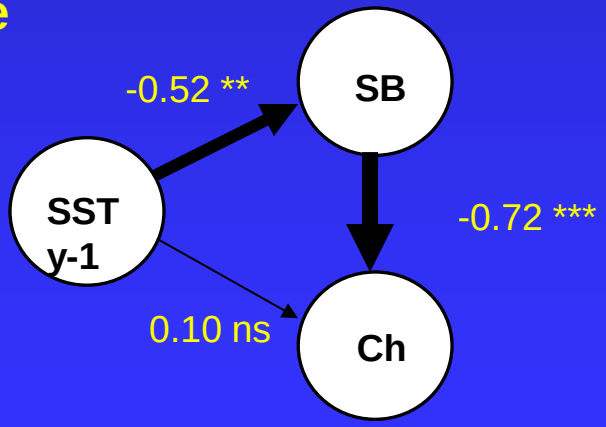
- *Semibalanus balanoides*
  - Negative correlation with SST previous June
    - High recruit mortality in warmer years?
    - Lower larval mortality in cooler years?
- Chthamalids
  - Positive correlation with SST previous June
    - Lower juvenile mortality in warmer years as poor survival of *S. balanoides* juveniles?

Is climate acting on each species directly or is climatic influence mediated by the presence of a competitor?

High Shore



Mid Shore



Causal Path Analysis

- SST the previous June directly influencing adult *S. balanoides* abundance only
- *S. balanoides* abundance influences adult Chthamalid abundance
- The influence of climate on Chthamalids is mediated by the presence of *S. balanoides*, the dominant competitor, in SW England

Model Output

Physically driven only

***S. balanoides* recruitment driven by SST**

Driven by climate and modulated by competition

***S. balanoides* recruitment driven by SST**

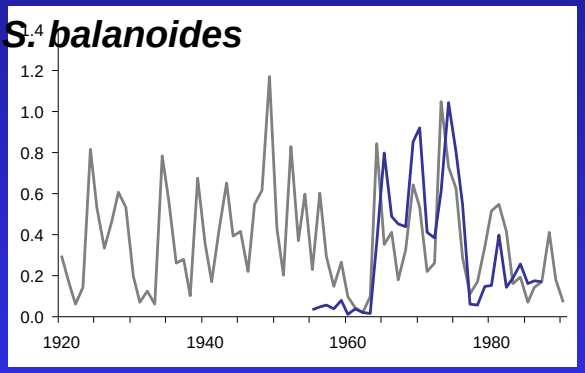
Interference competition between juvenile *S. balanoides* and Chthamalids

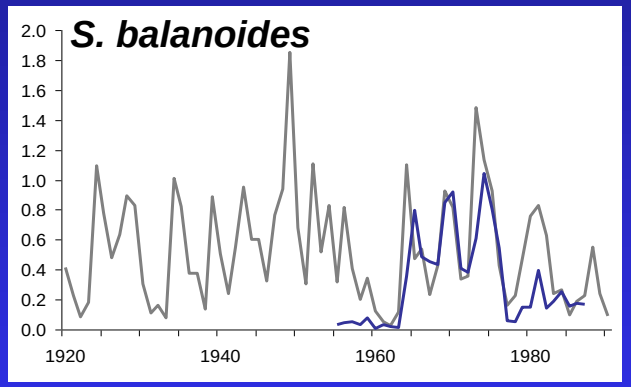
Historical abundance *S. balanoides*

Model output

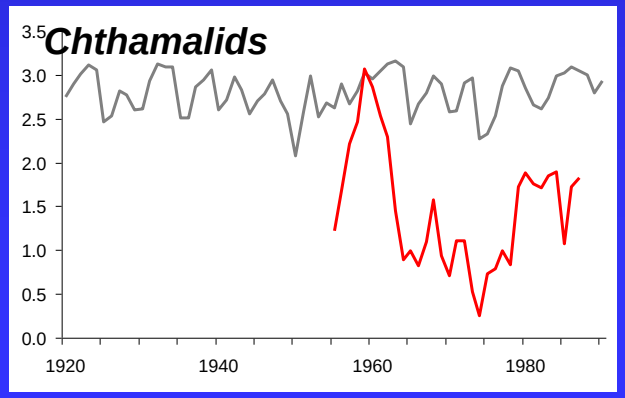
Historical abundance chthamalids

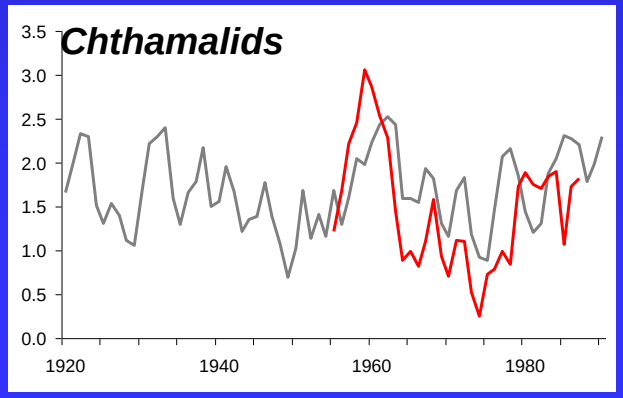
Adults per cm²





Adults per cm²





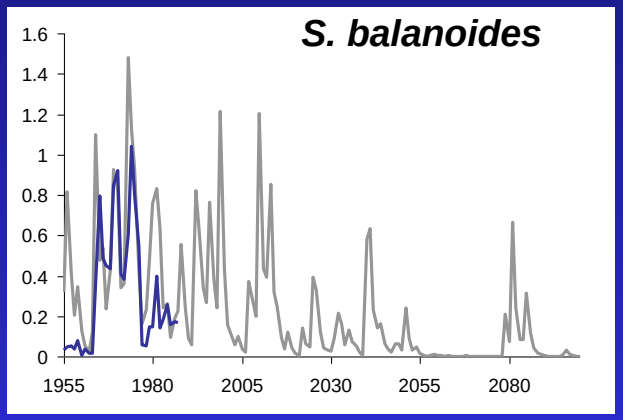
Model output incorporating competition: 1955 - 2100

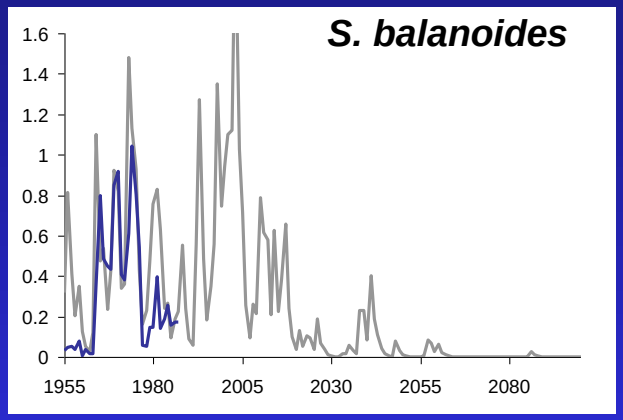
Low emissions

High emissions

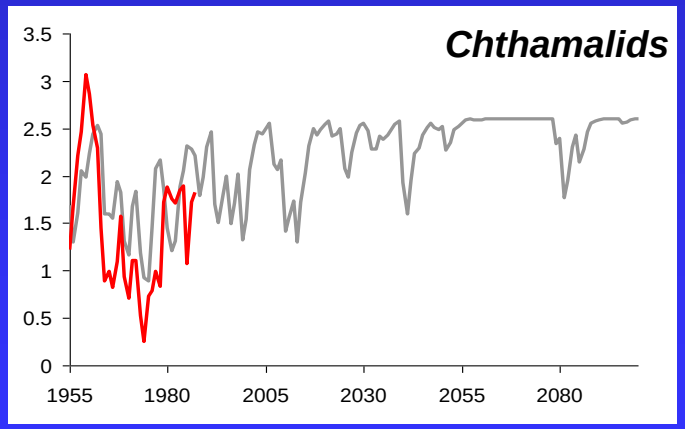
Historical abundance *S. balanoides*

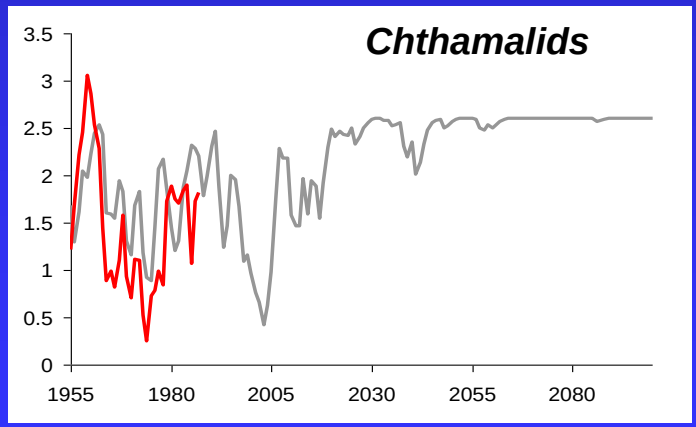
Model output





Historical abundance chthamalids

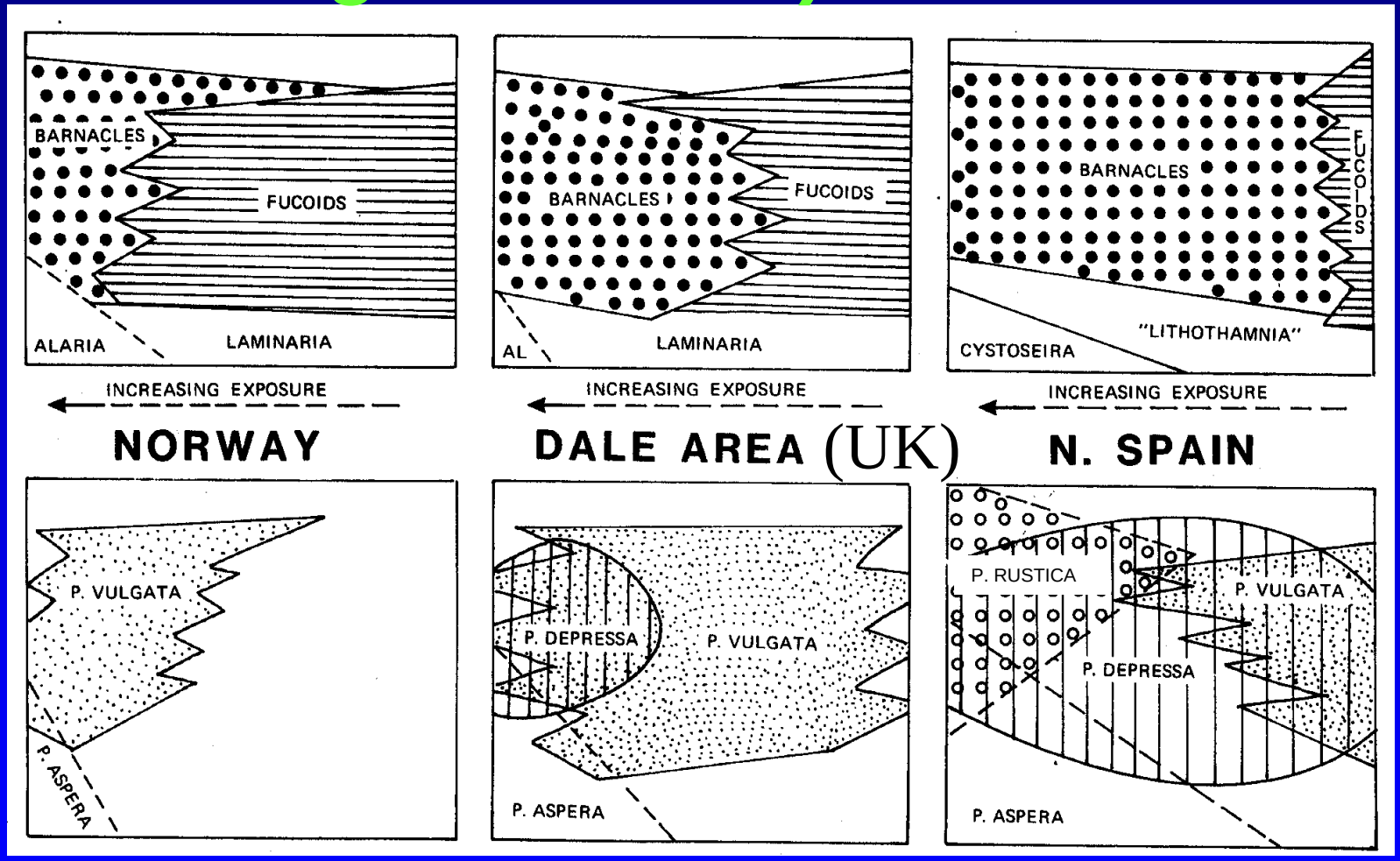




Polanczska et al: Ecology 2008 NERC grant and Marclim project

Ecosystem functioning - driven by climate?

Latitudinal shifts in fucoid (canopy forming seaweeds) dominance

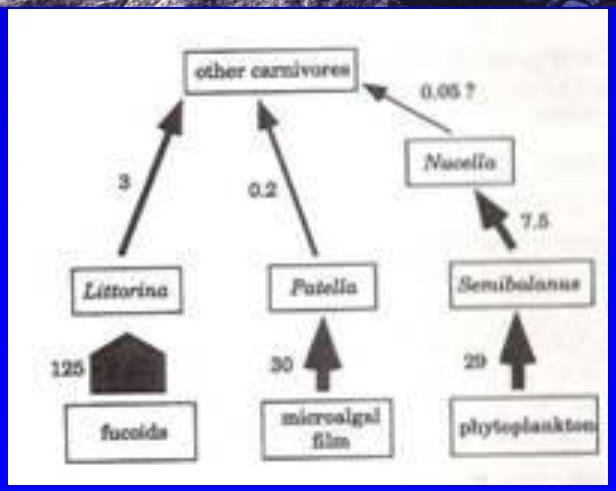


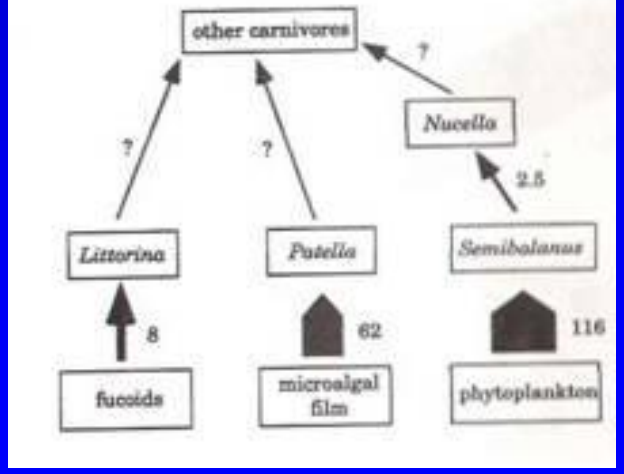
Hawkins & Hartnoll 1983 *Oceanography & Marine Biology Annual Review* 71: 55-72 from Ballantine 1961

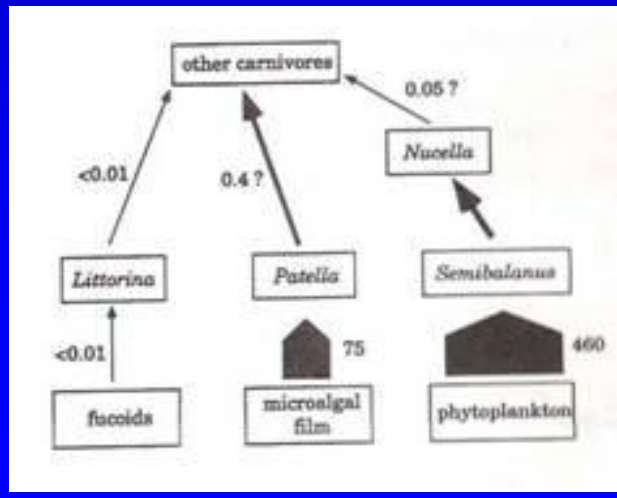
Natural fluctuations on moderately exposed shores

Rocky shore on Isle of Man

Climate change will result in assemblages dominated by suspension feeders and grazers







with less primary producers and export of detritus

Climate change – functional consequences?

- Northern rocky shores become more like those in southern Europe
- Balance between grazers/ suspension feeders & fucoids will alter
- Less canopy shelter and lower diversity
- Fewer primary producing fucoids and less detritus
- Shift from production being exported to importing rocky shores

Productivity lower!

Globalization

Harbour wall - Nelson, N.Z.

Elminius and *Mytilus*

S. Indopacific

Breakwater - Liverpool, U.K.

Mytilus and *Elminius*

N. Pacific & Atlantic

Homogenisation

Adaptation: manage interactions between global climate-driven change and regional and local scale impacts

- Non-native species (global climate change interacting with global biogeographic homogenisation)
- Fishing pressure and climate change (global & regional)
- Eutrophication, pollution and climate change (regional and local scale)
- Coastal development and climate change (local scaling up to regional scale)