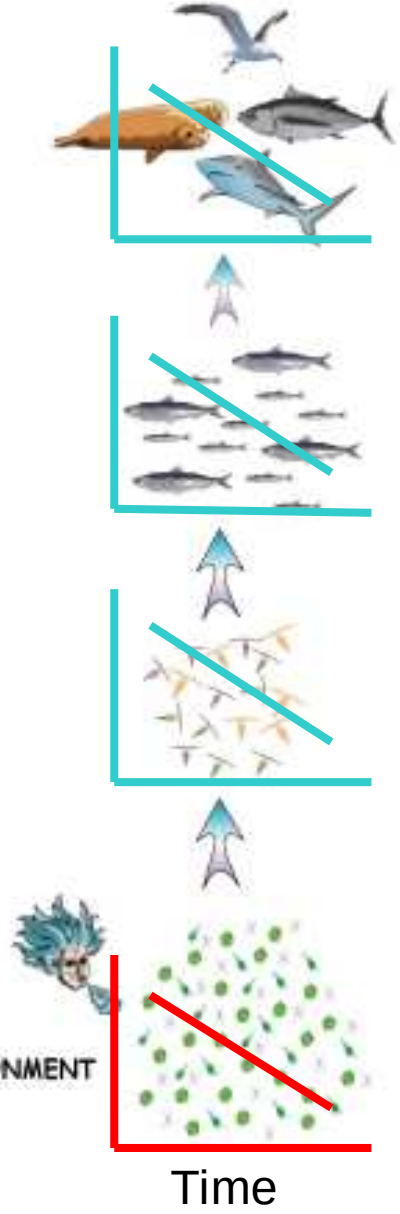
# Changes in the meroplankton of the North Sea, responses to climate and fishery.

J. Alistair Lindley

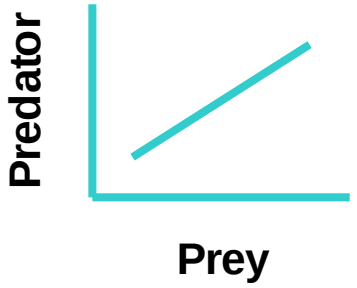
R. Kirby

G. Beaugrand

# Bottom-Up Ecosystem Control



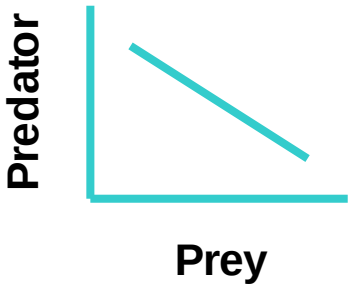

- Predators limited by prey (resource limitation)
- Traditional view in many marine systems
- Climate change propagates upward




Cury et al. (2000) *ICES J Mar Sci*

# Top-Down Ecosystem Control

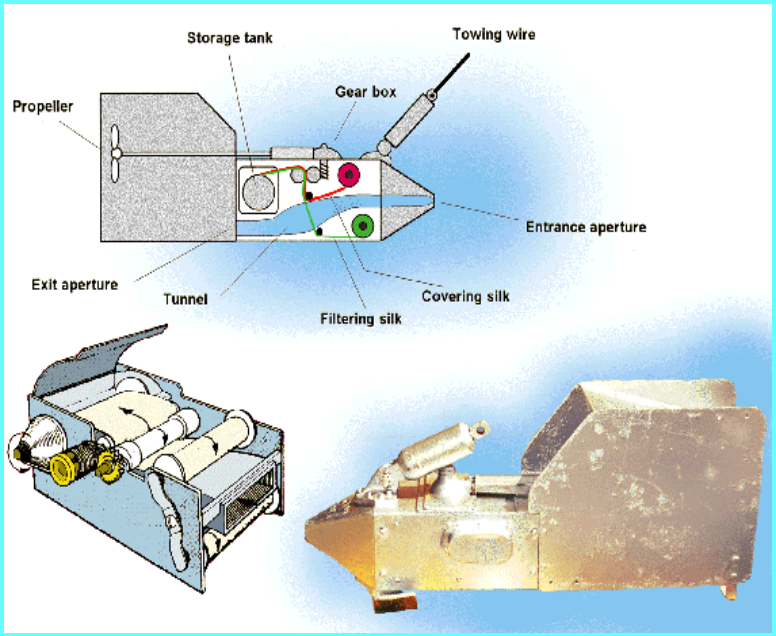

- Prey controlled by predators (predator limitation)
- Important in rocky shores, lakes and terrestrial systems?
- Effects of over-fishing cascade downwards



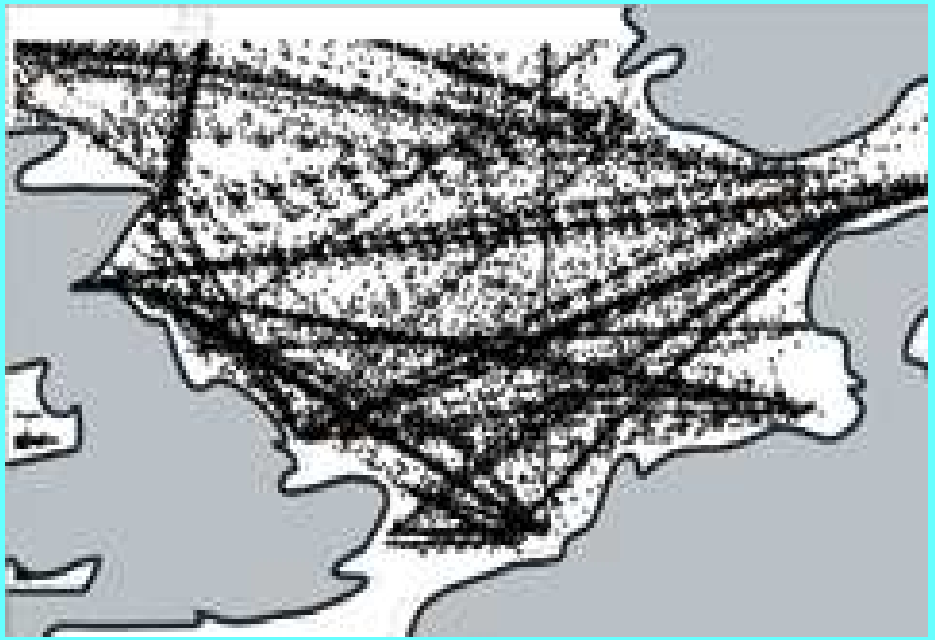

Cury et al. (2000) *ICES J Mar Sci*

CPR Survey and Climate

# The Continuous Plankton Recorder Survey



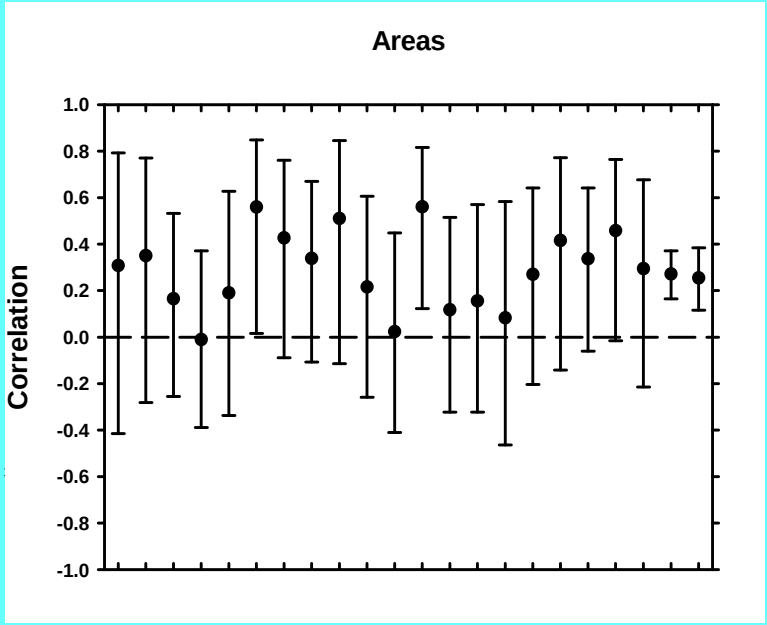

The CPR



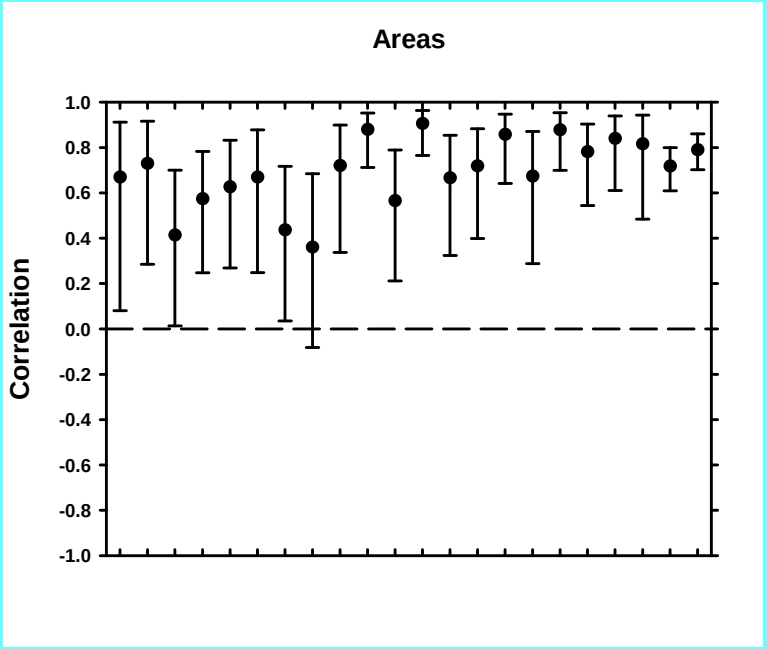
Towed by ships-of-opportunity, mainly merchant ships on regular routes

# Evidence for bottom up control in plankton

Herbivorous copepods vs Phytoplankton




Carnivorous zooplankton vs Herbivorous copepods

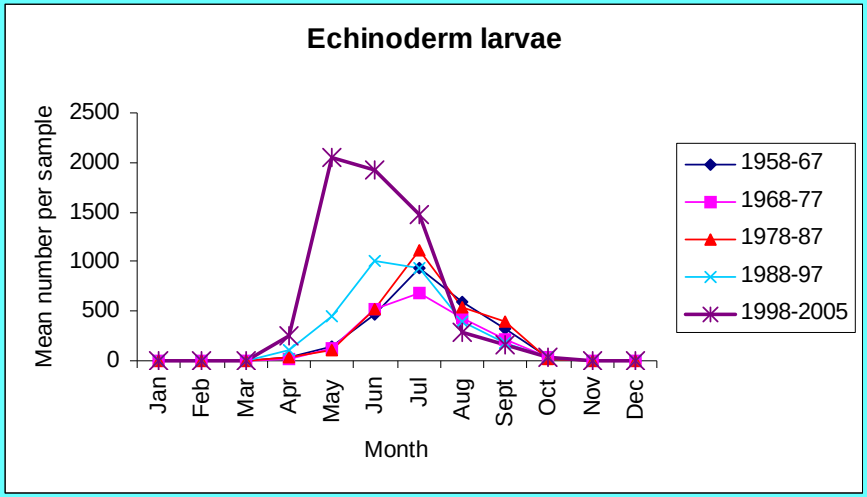


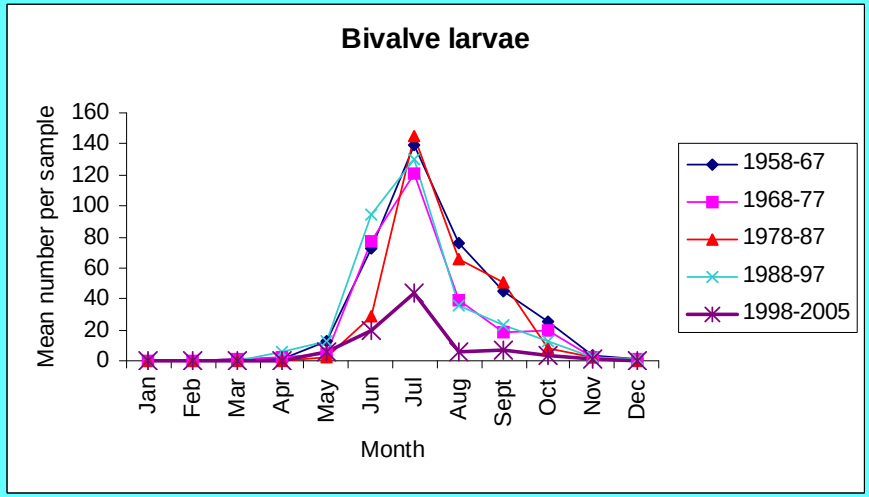

Richardson and. Schoeman, 2004). Science 305: 1609-1612.

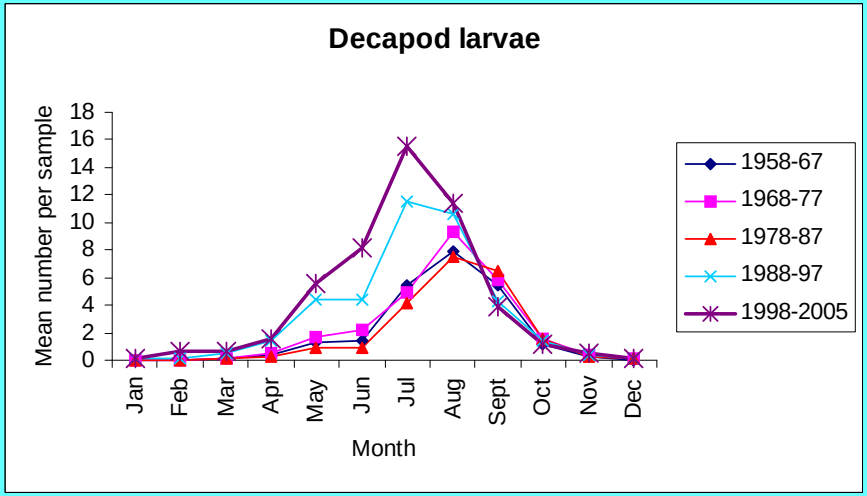
# Evidence for top - down control of benthos

- Results of Analysis by Heath (2005, IJMS, 62, 847-868)
- Supported bottom-up control in pelagic systems
- Found top - down control of benthos in the North Sea
  - Reduction in demersal fish
  - Decline in predation on benthos
  - Increase in benthic production
  - Increase in invertebrate fisheries (particularly decapods)
- Frank et al. (2005, *Science* **308**, 1621-1623) relate increases in decapods and associated changes in the holozooplankton to depletion of cod stocks off Canada.

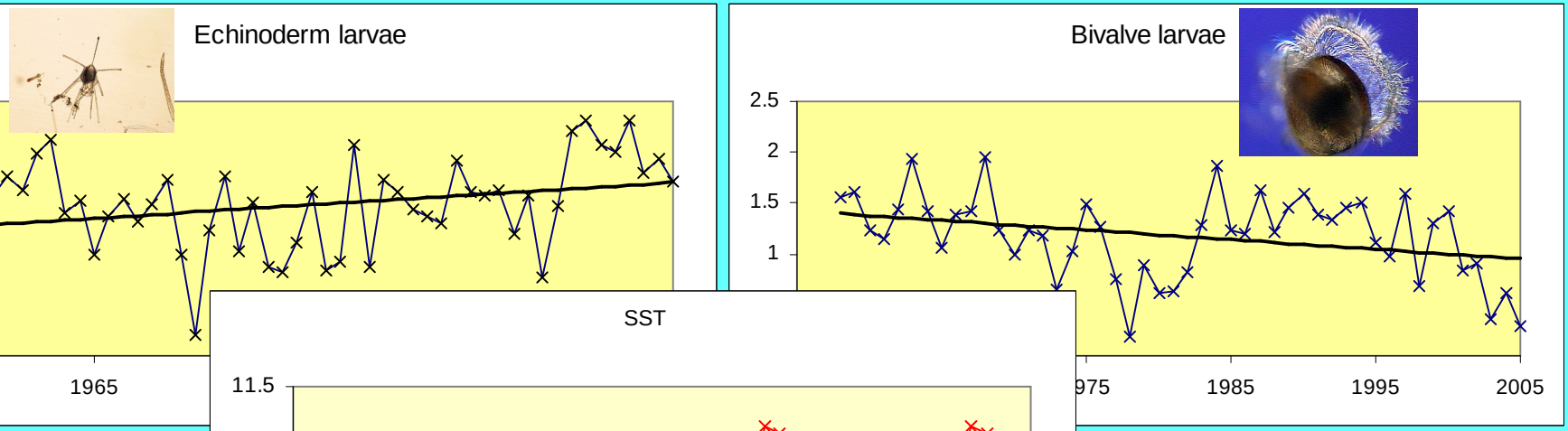
# Decadal changes in the seasonal cycles of three meroplanktonic taxa in CPR samples

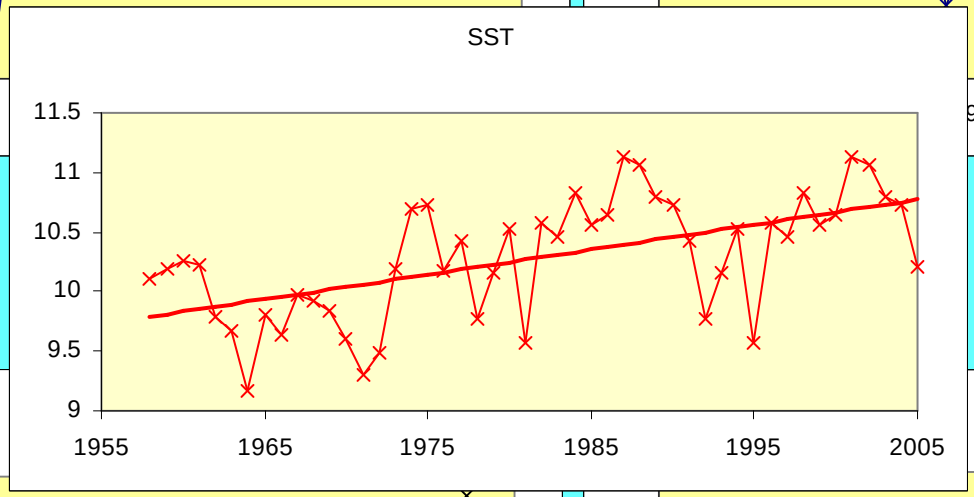


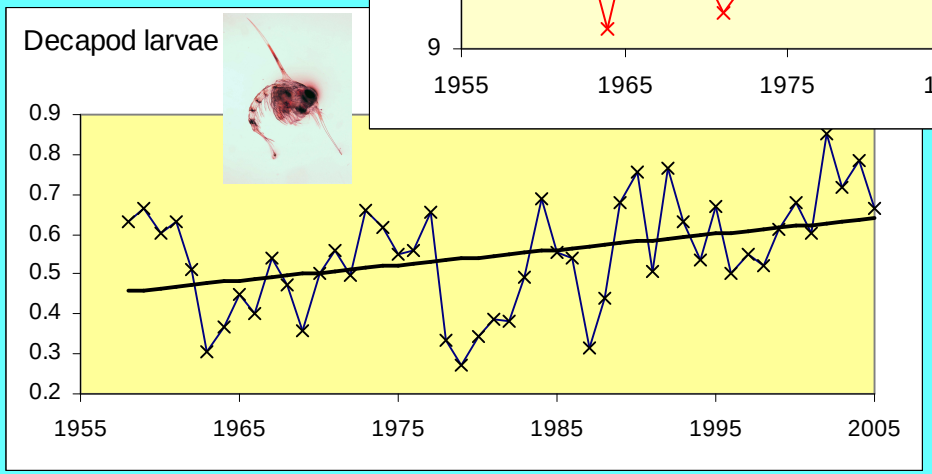



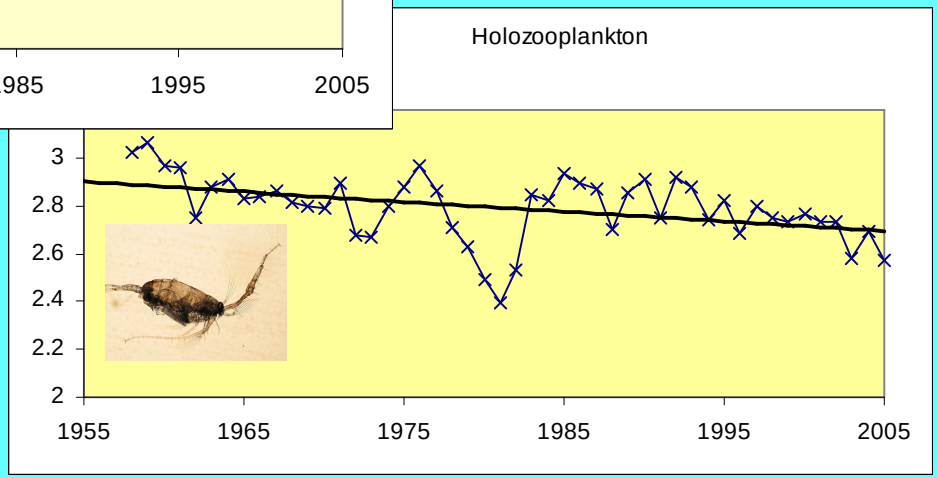



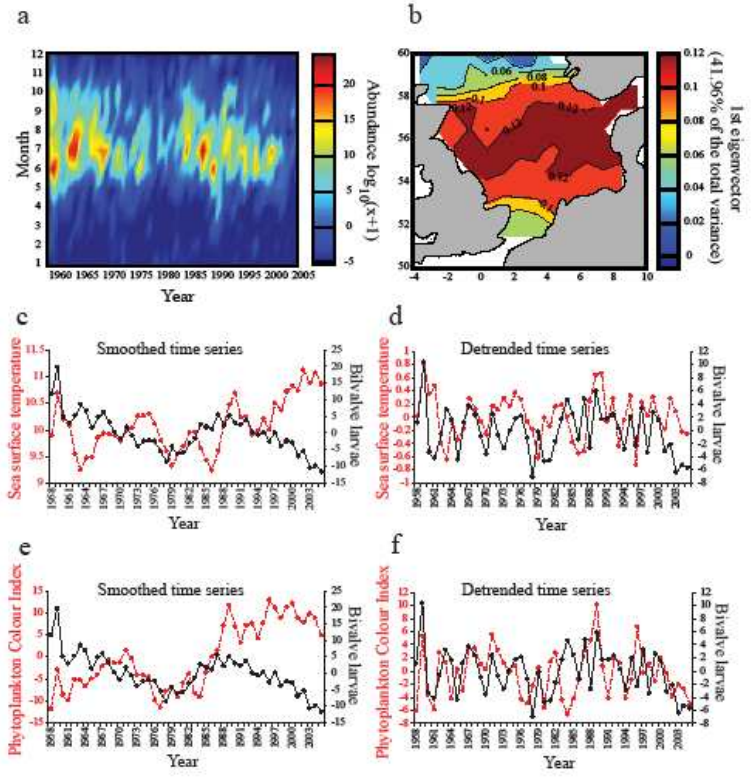
# Evidence of changes in benthos from variation in meroplankton





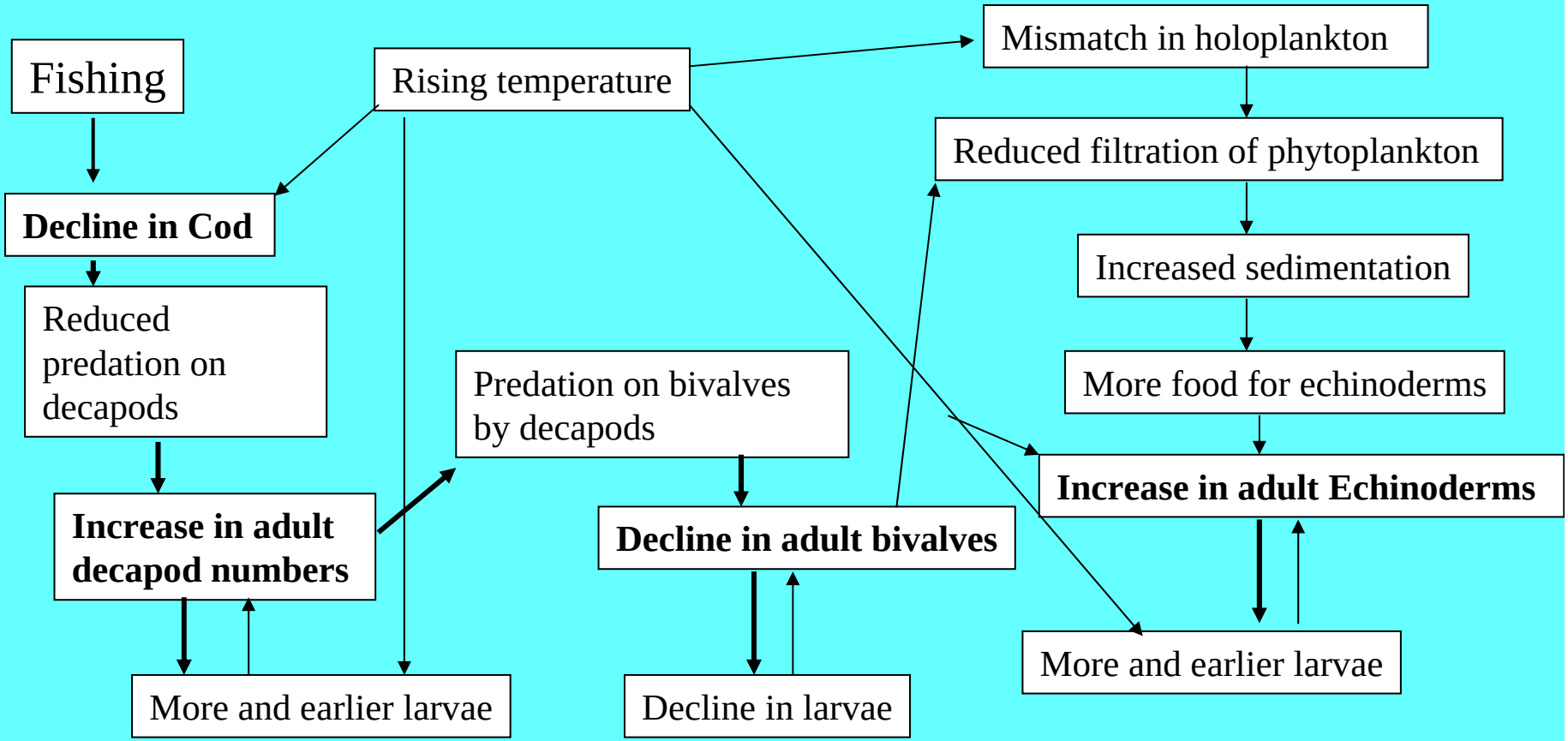

Kirby et al. In Press (L & O)

| Variables | r | p |
|---|---|---|
| Echino larvae/ SST Smoothed | 0.65 | 0.04 |
| Echino larvae/ SST Detrended | 0.41 | 0.0034 |
| Decapod larvae/ SST Smoothed | 0.86 | <0.0001 |
| Decapod larvae/ SST Detrended | 0.61 | <0.0001 |
| Bivalve larvae/ SST Smoothed | -0.27 | 0.33 |
| Bivalve larvae/ SST Detrended | 0.31 | 0.02 |

## Features of meroplankton variation and suggested mechanisms

- Dominant species of echinoderm larvae in samples is *Echinocardium cordatum* – a burrowing urchin dependant on sedimented material (Kirby and Lindley, 2005, J. mar. Biol. Ass UK, 85, 451-460)
- Changes in abundance and phenology of echinoderm larvae correlated with temperature, particularly in winter and spring (Kirby et al., 2007, Mar. Ecol. Prog Ser. 330, 31-38.
- Detrended data show that bivalves as well as echinoderms and decapods respond positively to temperature but bivalves show long term decline. (Analysis by G. Beaugrand)
- Proposed mechanism is predation by decapods on bivalves (Kirby et al. In Press).
- Synergistic effects of temperature and predation pressure on decapods. (Analysis underway)

# Proposed top-down control



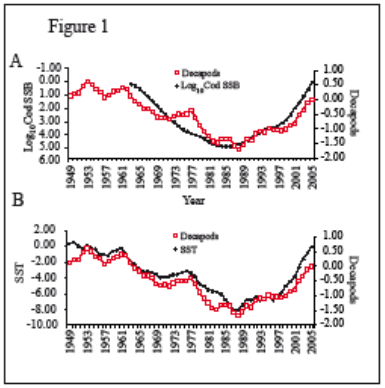
# Cumulative sums analysis – Grégory Beaugrand

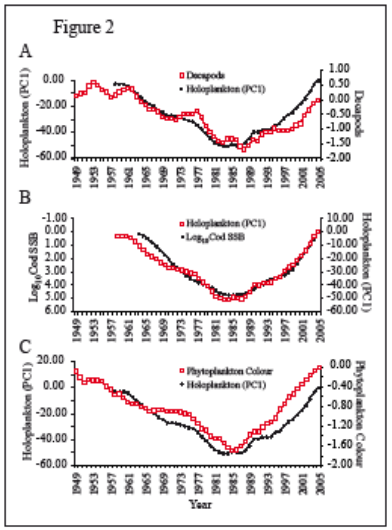
“Cumulative sum (CUSUM) control charting is a valuable tool for detecting and diagnosing persistent shifts in series of readings.”

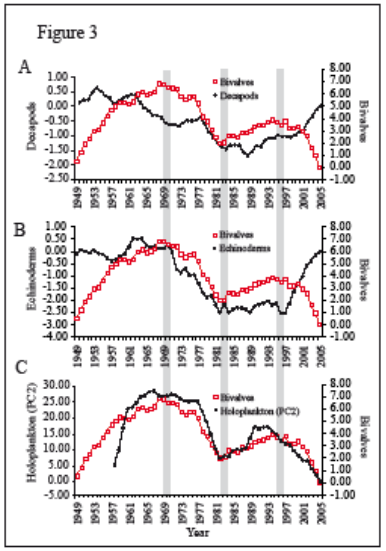
Consistent Pattern for Decapods, cod SSB, SST, Phytoplankton, Holozoooplankton PC1 and Echinoderms

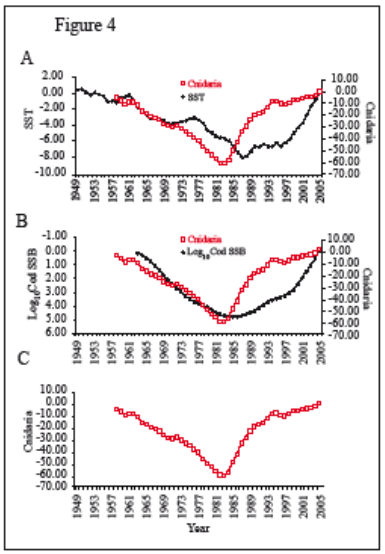
Bivalves and Holozooplankton PC2 show common trends

Coelenterates – distinctive pattern



# Questions arising.

- Decapod larva are predators of zooplankton – does the increase in numbers of decapods contribute to decline in holoplankton?
- Reductions in fish stocks can result in increased jellyfish numbers – which in turn impact on the fish populations and increases pressure on the zooplankton (Lynam et al. Current Biology, 16, R492-R493). Have the fisheries in the North Sea stimulated an increase in jellyfish abundance (Attrill et al. 2007) with consequent increased predation on the holozooplankton?
- Will decline in numbers of bivalves eventually limit the decapod population?