Workshop on Identifying and Co-ordinating Research as an Adaptation to Climate Change
in the South African Marine Fisheries and Marine Aquaculture Sectors,
Cape Town, 14-16 March 2017

Session 2: Are our oceans changing in response to climate change?

Zooplankton

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- Marine plankton comprise phyto- and zooplankton that provide **food and energy** for other marine life. Without plankton there would be no marine **ecosystem services** (c. US$21 trillion p.a.), including fish production, nutrient cycling, gas production and climate regulation.

- Because they are abundant, short lived, not harvested, and highly sensitive to changes in temperature, nutrients and acidity, plankton provide ideal **indicators of environmental change**.

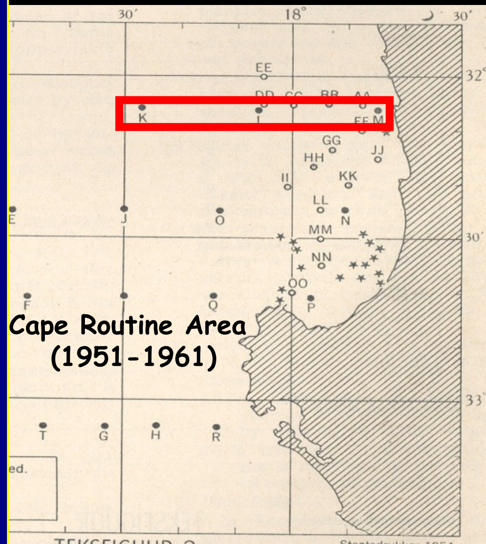
- Plankton indicators such as basic **bulk status variables** (e.g. total abundance, total biomass, mean size) are internationally known as '**Essential Ocean Variables**' (EOVs) and are particularly useful for the assessment of marine **biodiversity** and **ecosystem health**. They have a high feasibility of sustained observation.

- Focus is on **Copepods**, the most common and most abundant zooplankton. Bulk indices are less sensitive to environmental change and may mask the subtleties provided by individual species, but they represent the general functional response of plankton to a changing marine environment over multiple decades.

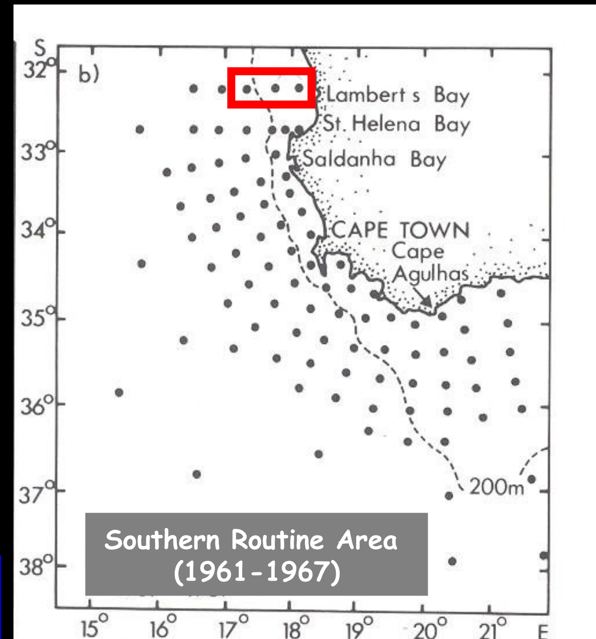
- **Updated (2016)** multi-decade time-series of copepod abundance, species composition and community size structure on the west and south coasts of SA will be presented.

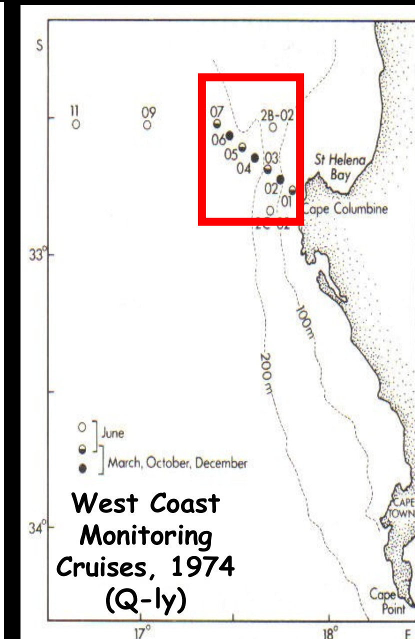
WEST COAST: St Helena Bay time-series

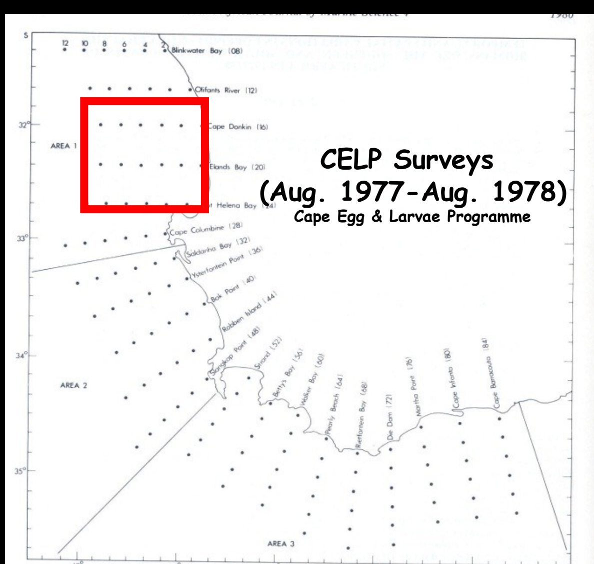
Long-term zooplankton time-series constructed from retrospective analysis of selected AUTUMN samples from 8 sampling programmes, 1951-2016

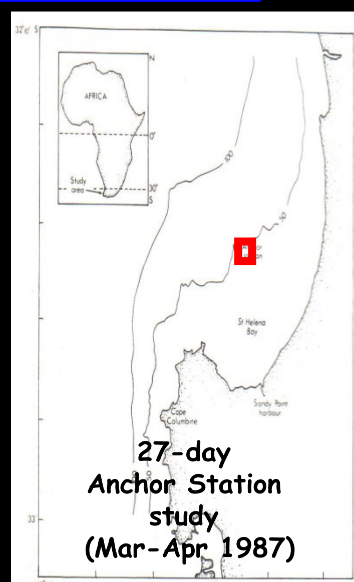


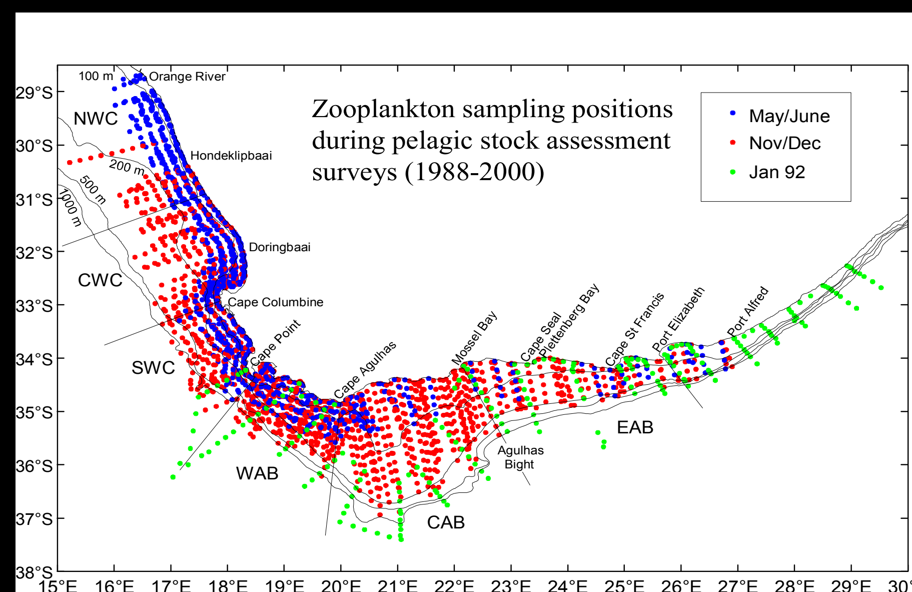
Minor methodological differences – accounted for



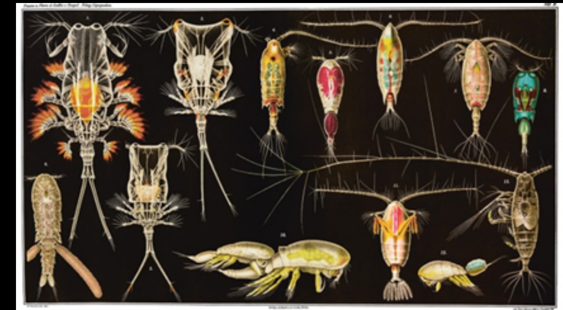


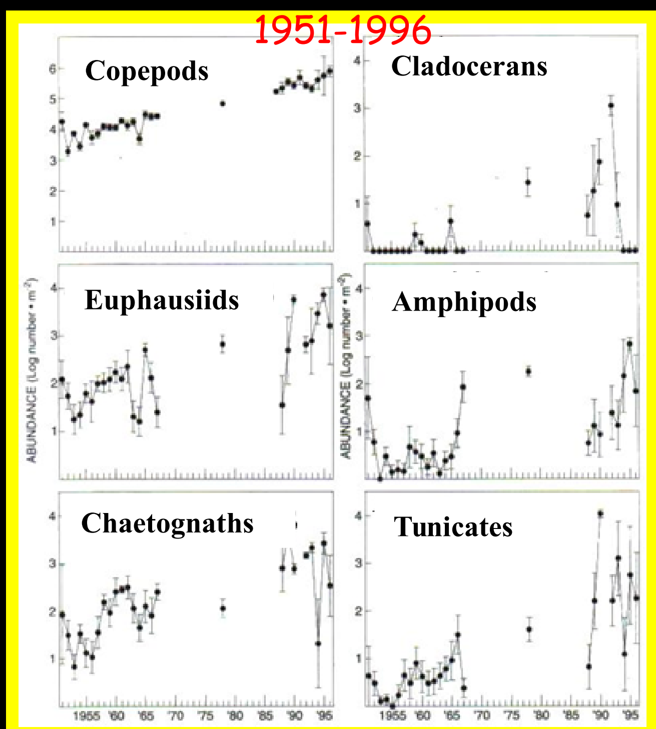




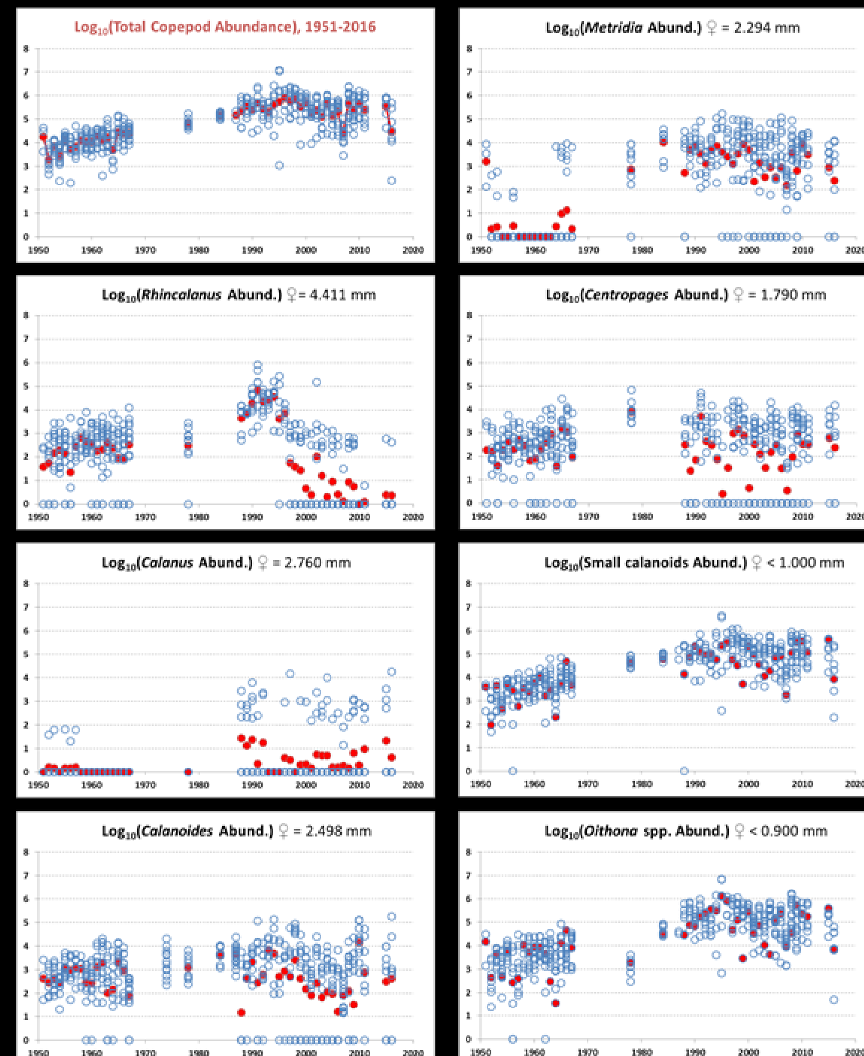


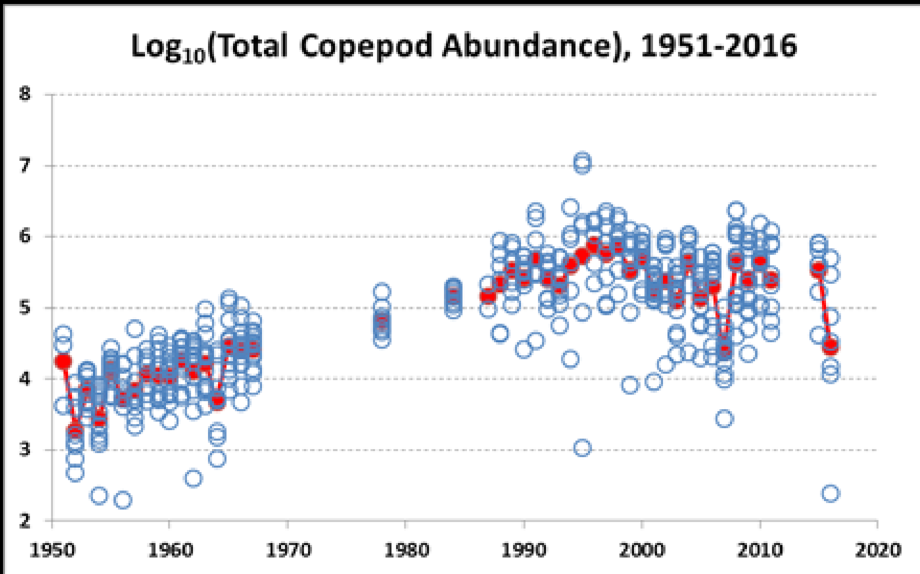
1. Long-term **increasing** trends in meso- & macrozooplankton abundances;
   + large interannual variability.
2. Populations show differential rates of increase/decrease over time;
   ✉ change over time in **community structure** (e.g. copepod <u>species</u> & <u>size</u> composition)





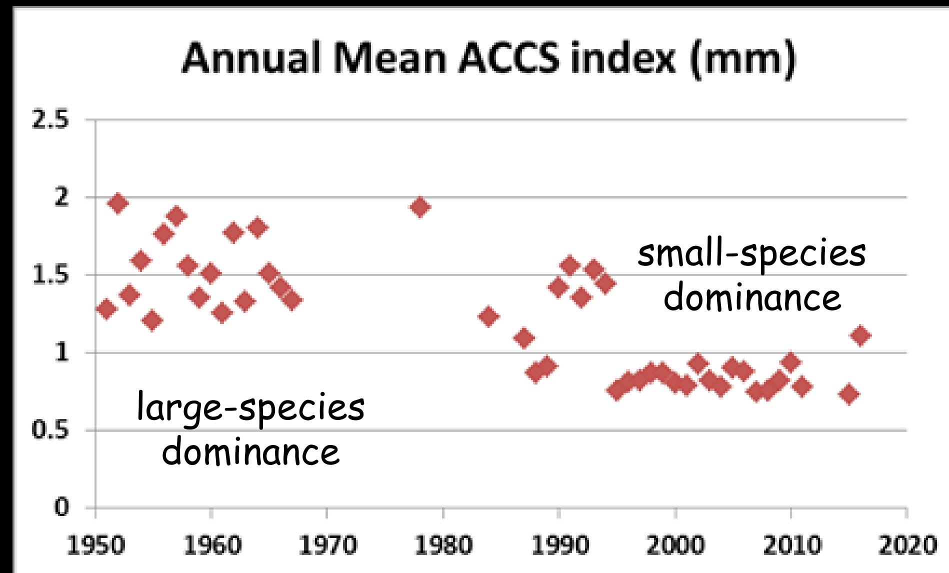
(Verheye et al. 1998, Verheye 2000)



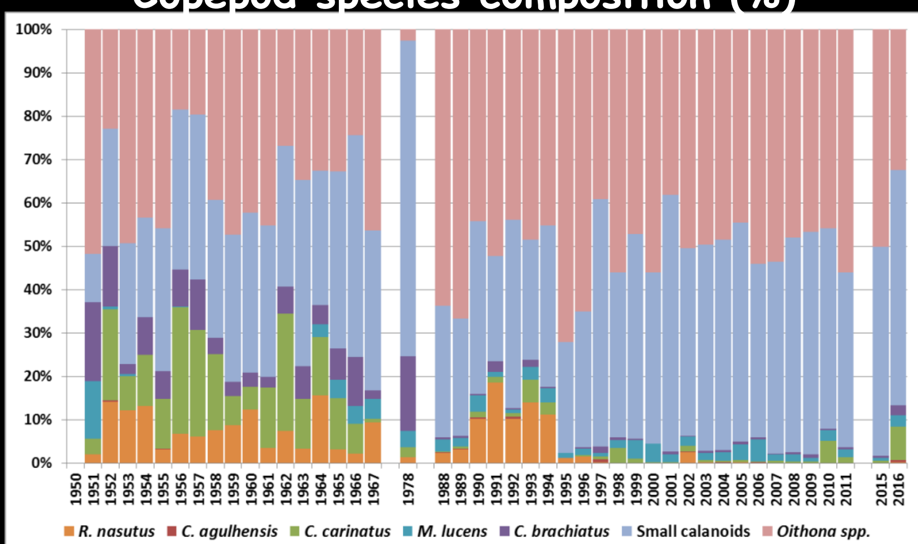


ACCS index (Average Copepod Community Size)

= zooplankton size index based on abundance and body length of adult female copepods (=weighted mean body size)



Copepod species composition (%)



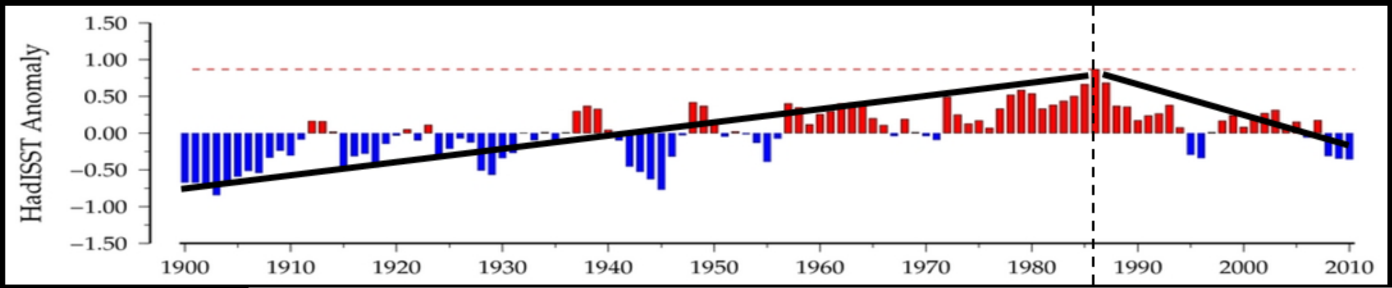
Body size: large spp. ✉ small spp.

Shift in autumn copepod community size structure, from large-species (>1 mm; 1950s–1960s) dominance to small-species (<1 mm; mid-1990s–2000s) dominance

= usually indicative of ocean warming!!

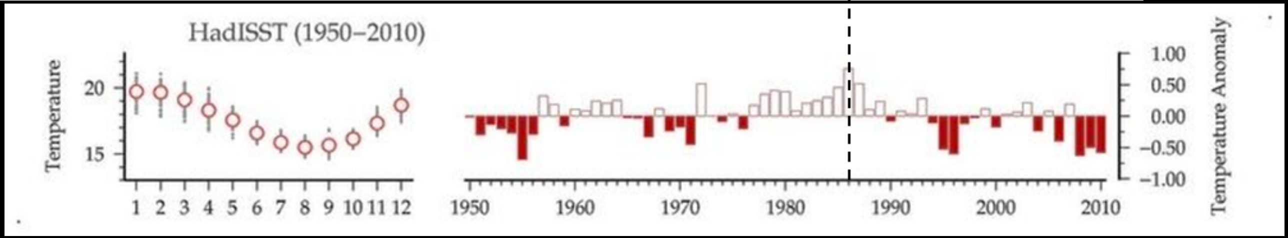
However …

Southern Benguela: St Helena Bay (32.5°S)



- L-T warming
- Cooling: m-80s
- incr. SE winds
- incr. upwelling

(Rouault et al. 2010)

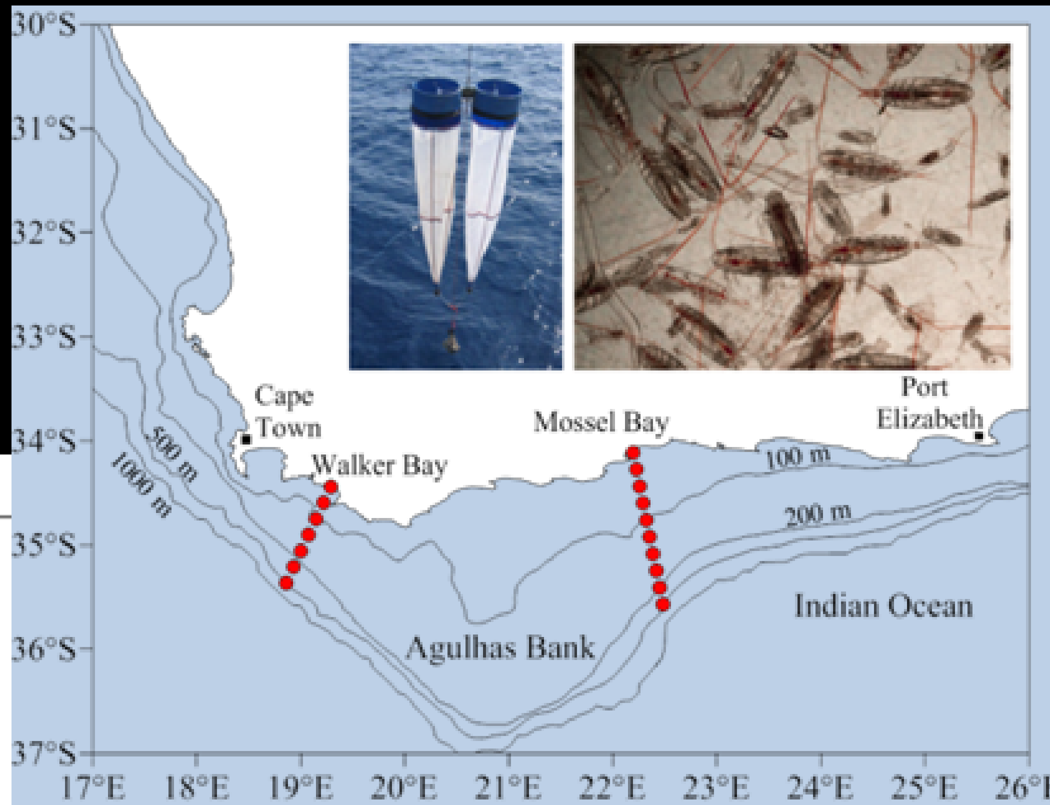


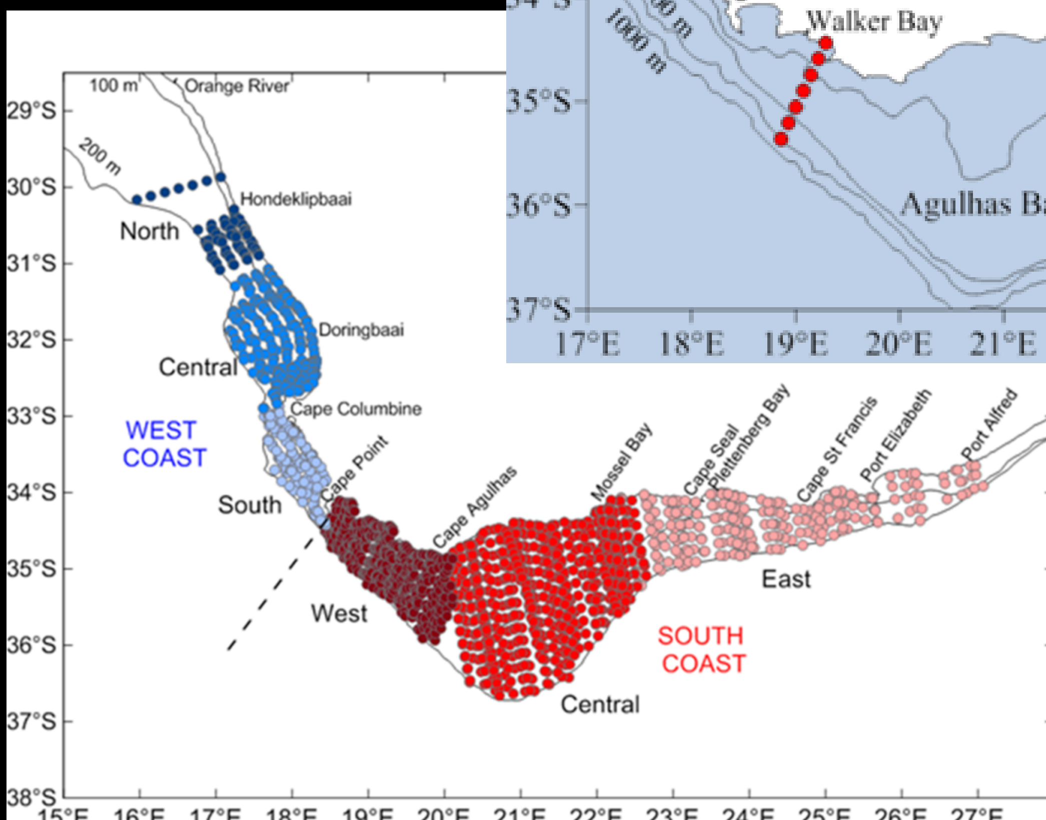
So … shift in SHB to a smaller ACCS, although usually indicative of ocean warming, is likely a consequence of <u>predation</u> by anchovy recruits preying size-selectively on medium/large copepods (*Centropages*, *Calanoides*, *Rhincalanus*), possibly blurring the effects of intensified upwelling (+cooling) on enhanced PP and the productivity of these upwelling copepod species.

= BOTTOM-UP + TOP-DOWN control of zooplankton

SOUTH COAST: Walker Bay & Mossel Bay time-series

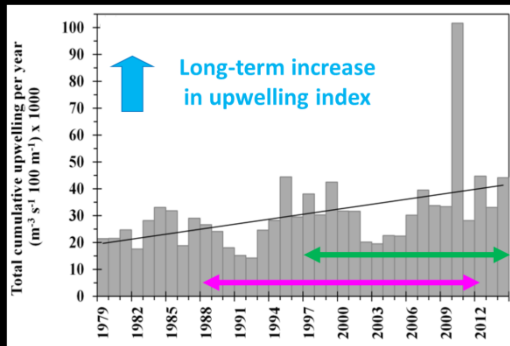
Annual Pelagic
Spawner Biomass Surveys
late **spring**/early summer
1988 - 2016

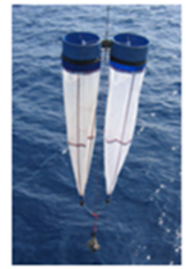


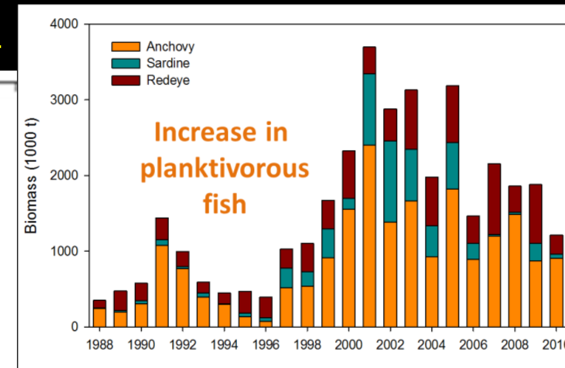


South Coast 1988-2011

Upwelling index







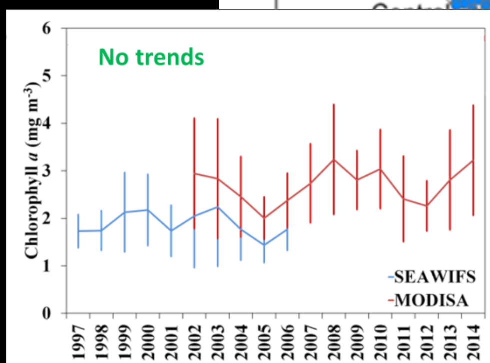
Fish biomass & spp.

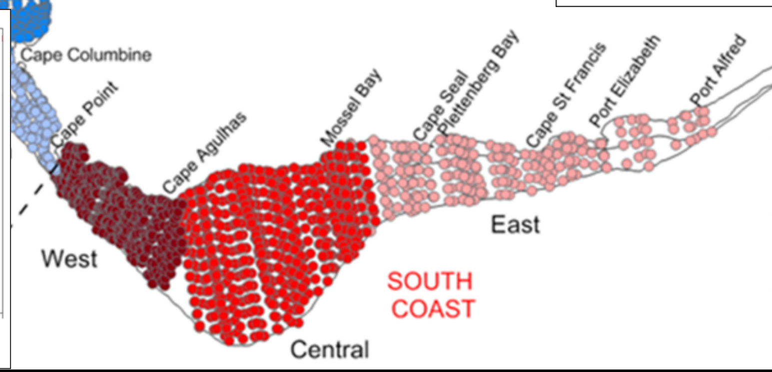
Total Chl *a*

Micro (>20 µm)

Nano (2-20 µm)

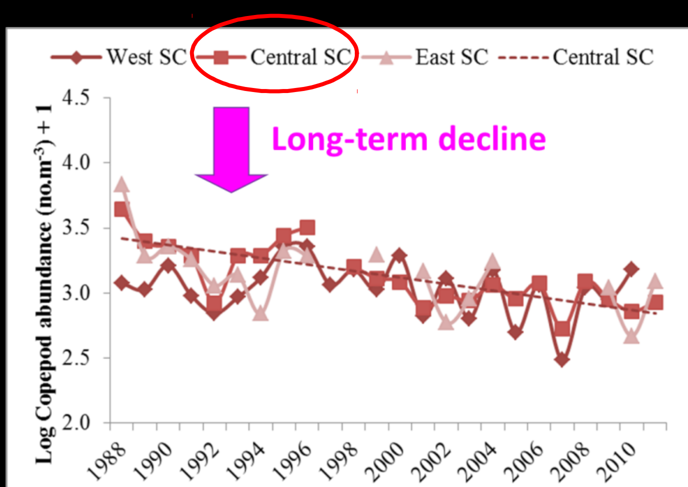
Pico (<2 µm)



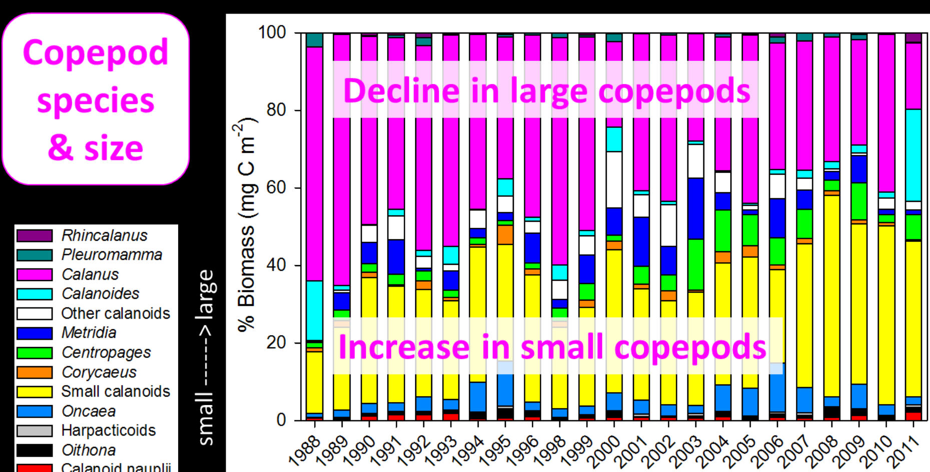


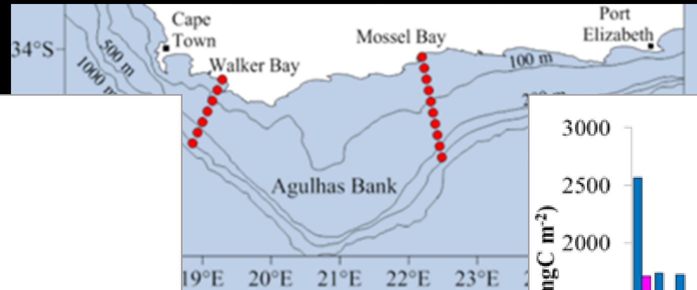
Changes in copepod community more likely a consequence of top-down control, through increased size-selective predation, than bottom-up forcing.

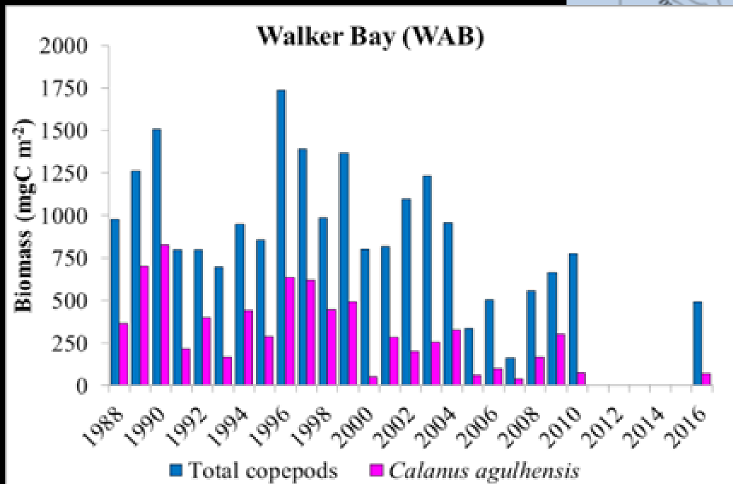
Copepod abundance

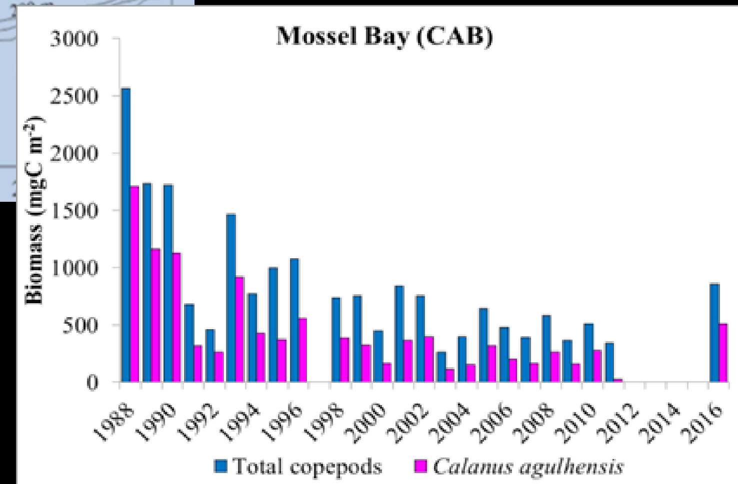


Copepod species & size

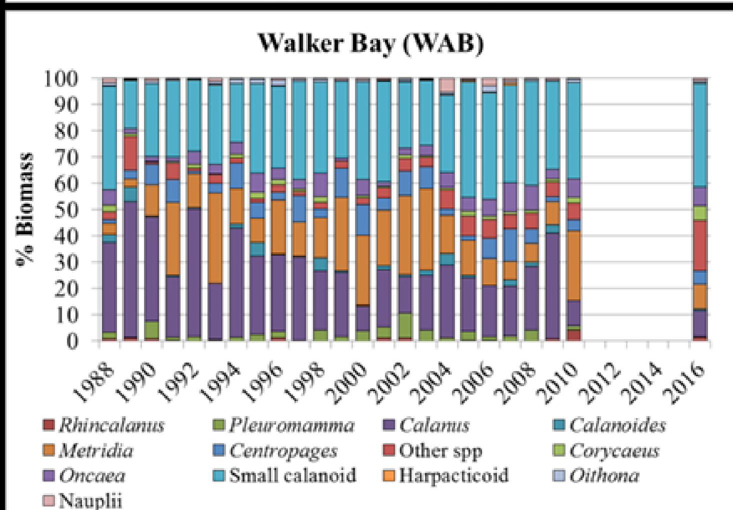


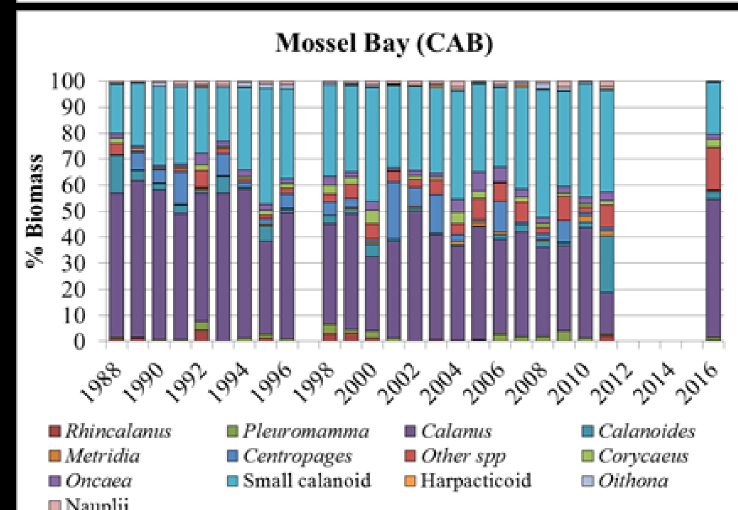






1988-2016





- Copepod biomass (B) quite variable over TS, but gradual decline in B since 1996 peak;
- LT decline in B of *C. agulhensis*;
- LT decline in proportion of *C. agulhensis* since 1988.

- Significant LT decline in B of both total copepods and *C. agulhensis* since 1988;
- LT decline/increase in proportion of *C. agulhensis*/small calanoid species;
- Sudden or gradual reversal in 2016: ???

CONCLUSIONS:

During the past 7decades trends in abundance, biomass, and species and size composition of copepod communities have changed substantially off South Africa.

On the West Coast, copepod abundance increased from the 1950s onward, until a turning point around the mid-1990s after which abundance declined. There was also a shift from large to smaller species dominating the copepod communities. Such changes may be linked to an ecological regime shift, likely induced by environmental changes but exacerbated by a shift in prey size-based predation pressure by pelagic fish.

On the South Coast, total copepod abundance declined since the late 1980s. Changes in copepod species composition indicate a gradual decline in the proportion of *Calanus agulhensis*, the dominant large copepod on the South Coast, with a corresponding increase in the proportion of small copepod species. A reversal is likely to have occurred recently.

These major changes reflect patterns of spatial, temporal and size-based heterogeneity in the region and are thought to be mediated locally and differentially through bottom-up and top-down forcing mechanisms. While the relative importance of these control mechanisms remains uncertain, changes in the plankton observed off South Africa have fundamental implications for biogeochemical processes, food web structure and ecosystem functioning, as well as for the ecosystem services supported by the plankton.

Because plankton are ideal indicators of ecosystem change, continued systematic monitoring of their communities in the region is essential to understanding the long-term impacts of these changes.