

Regime shifts in the Northern Benguela: challenges for management

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Hypothesis:

Ecosystem has reorganised over the past 50 years due to cumulative effects of overfishing and environmental drivers. The system has changed significantly and needs to be managed as such.

Methods:

EwE model for 1956, fitted to timeseries 1956-2003

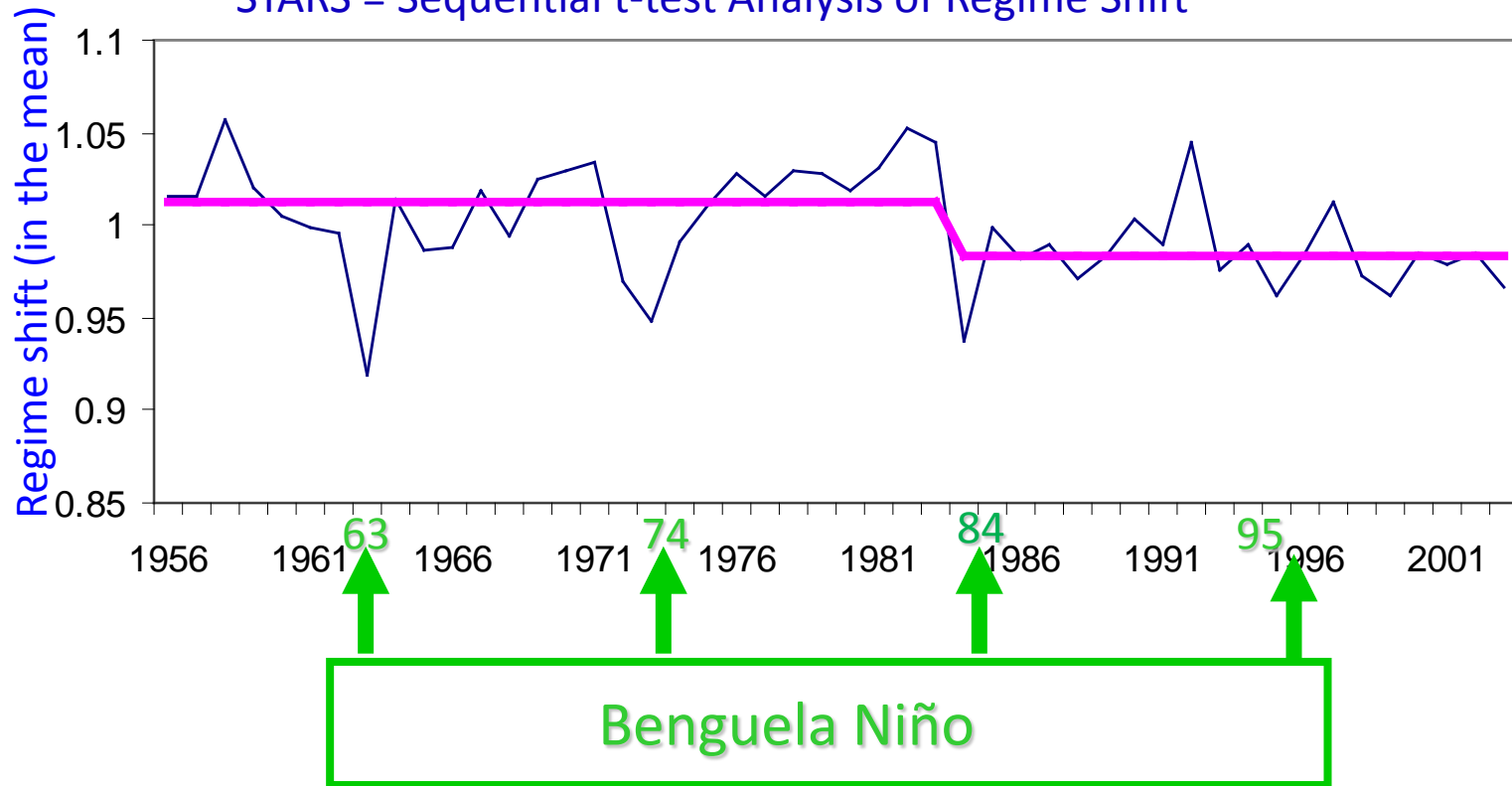
Integrated Trend Analysis – PCA, STARS, CC of input data, model output, network analysis indices

Heymans, et al. 2009. "Policy options for the northern Benguela ecosystem using a multispecies, multifleet ecosystem model." [Progress in Oceanography 83: 417-425.](#)

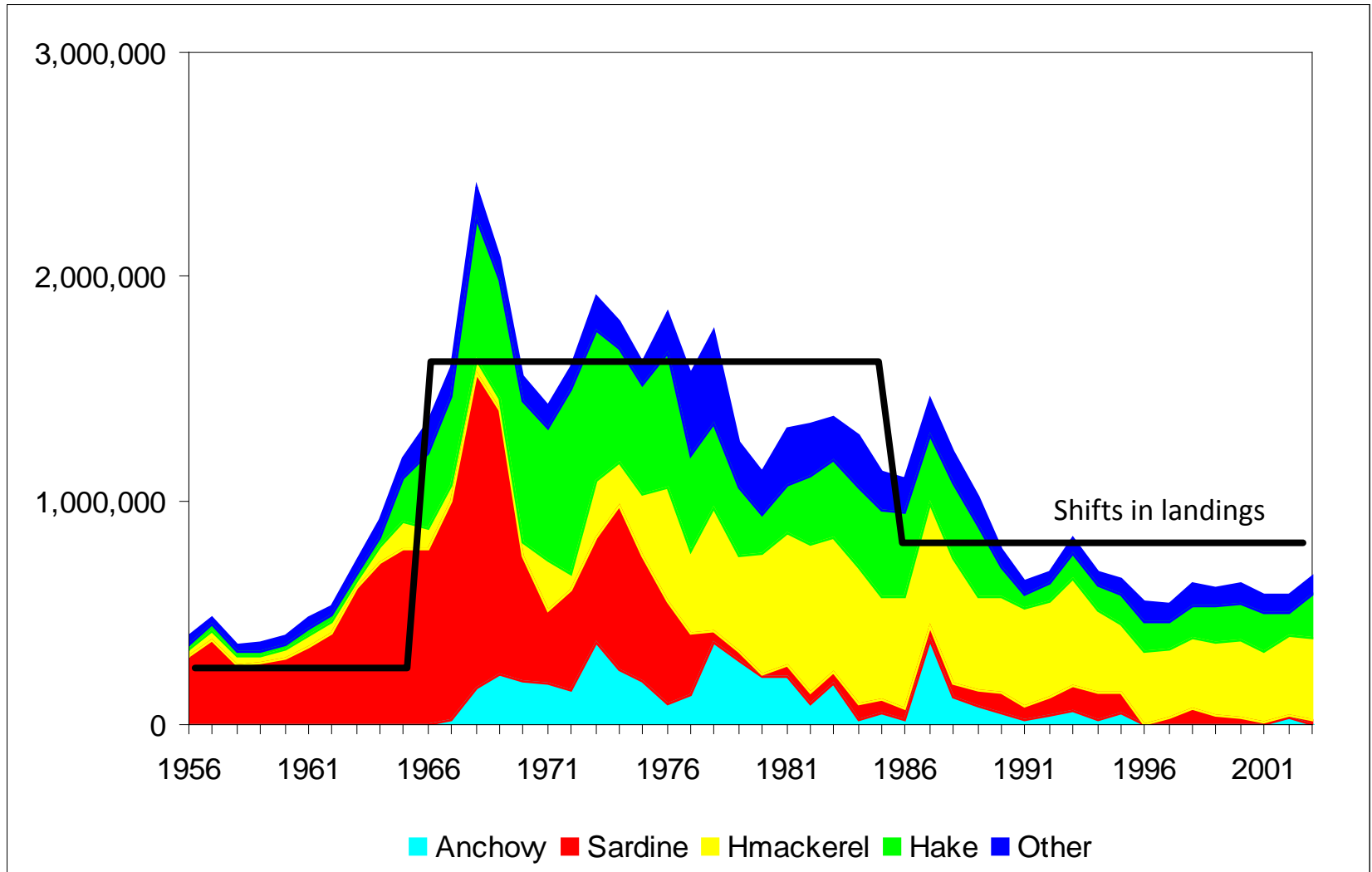
Environmental driver

Shifts in the mean for anomaly, 1956-2003
Probability = 0.1, cutoff length = 5, Huber parameter = 1
AR(1) = 0.00 (OLS), subsample size = 3
Shift detection: After prewhitening, Plot: Original data

STARS = Sequential t-test Analysis of Regime Shift

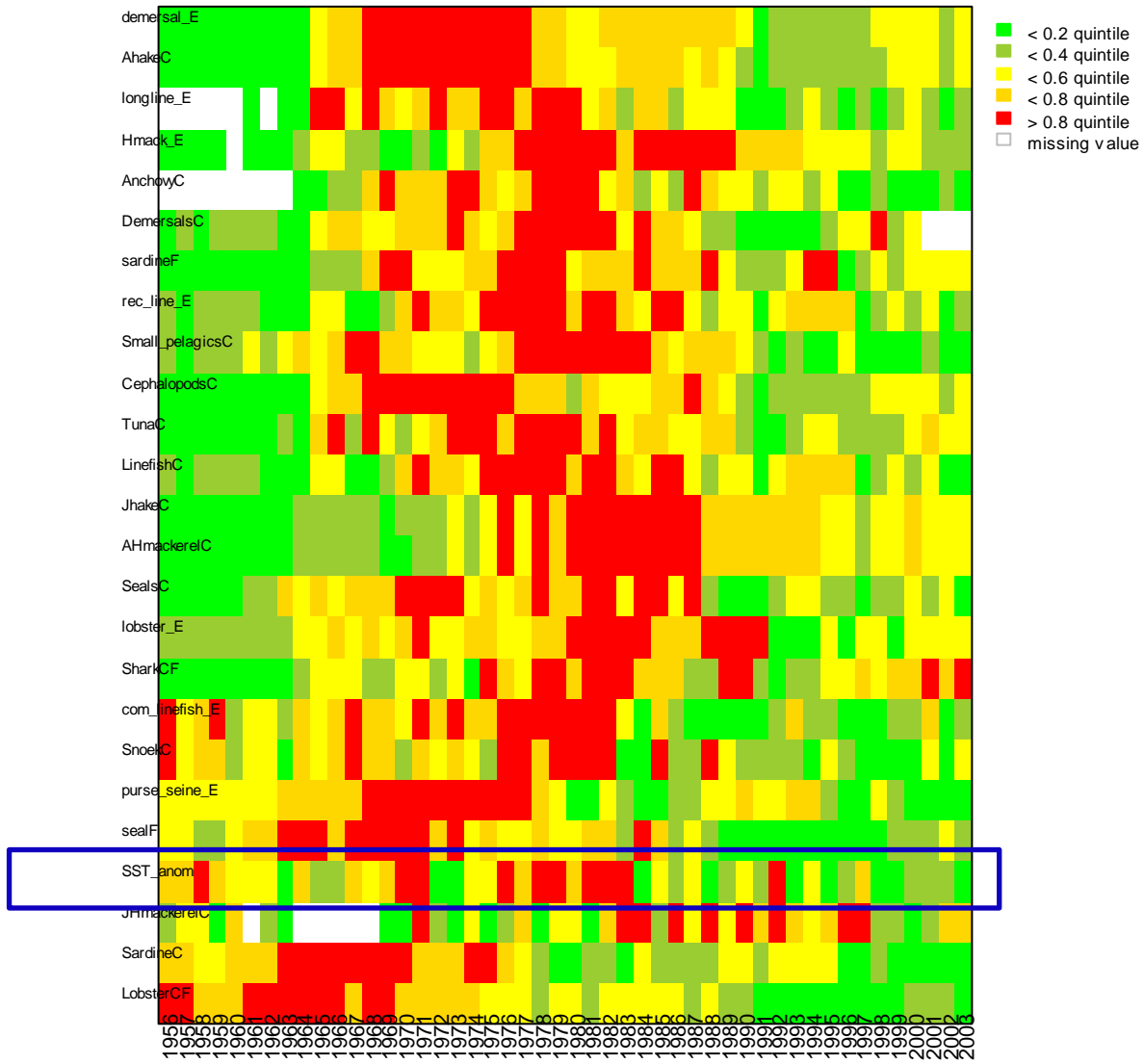


Northern Benguela landings



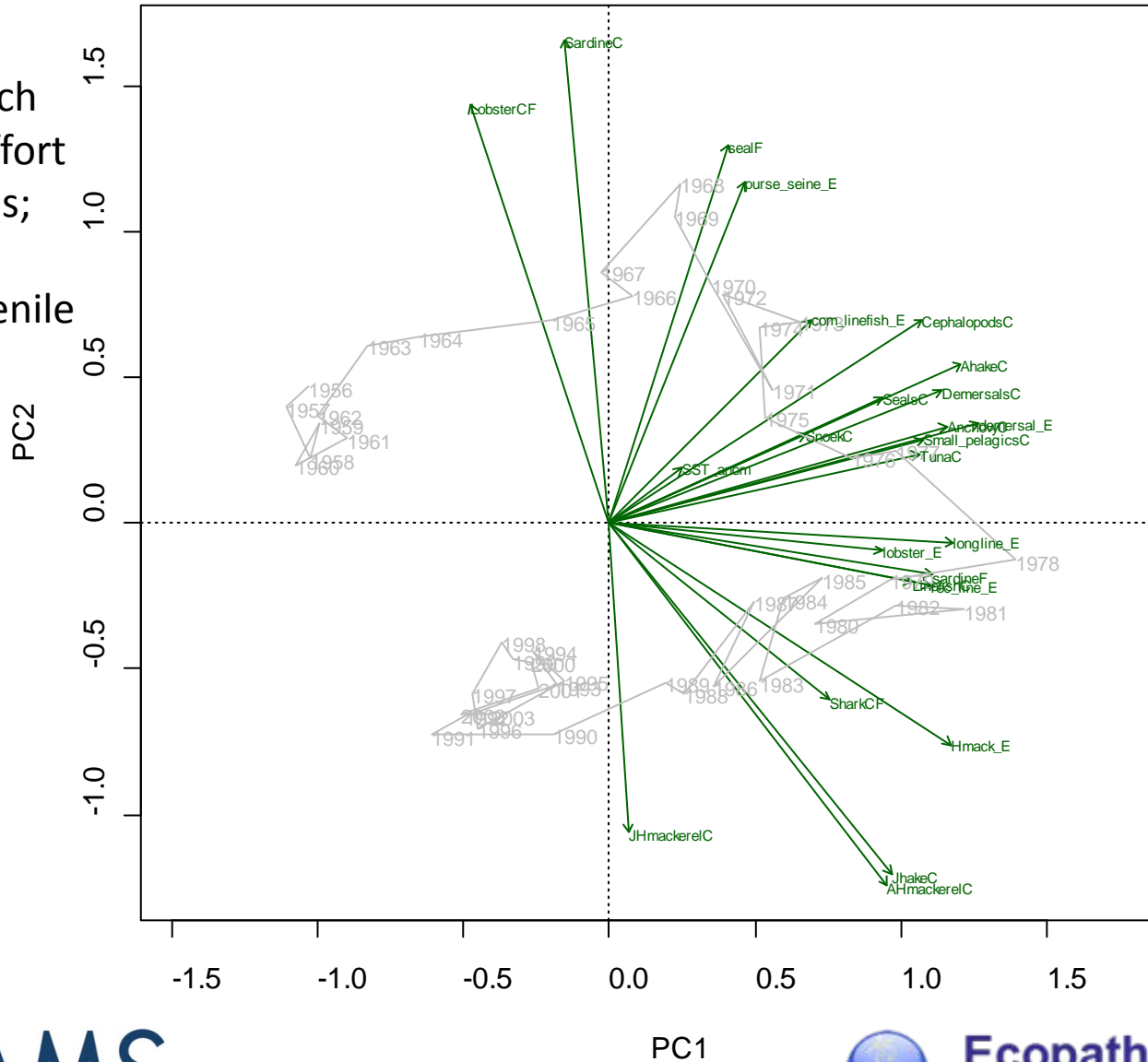
Variables (sorted by their loading on the 1st PC

Traffic Light Plot

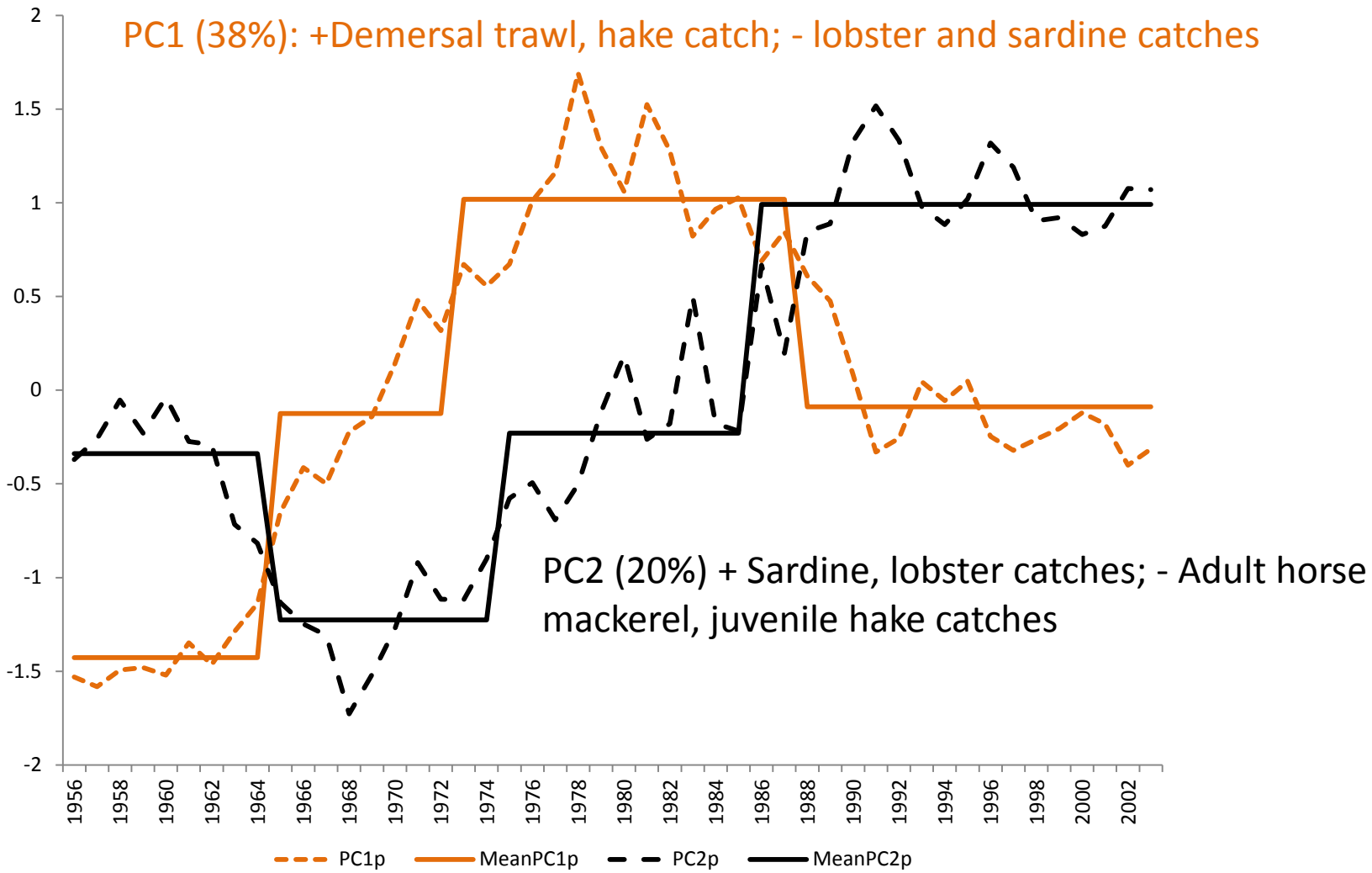


Biplot with time trajectory

PC2 (20%):
 + Sardine Catch
 Purse seine effort
 lobster catches;
 - Adult horse
 mackerel, juvenile
 hake catches

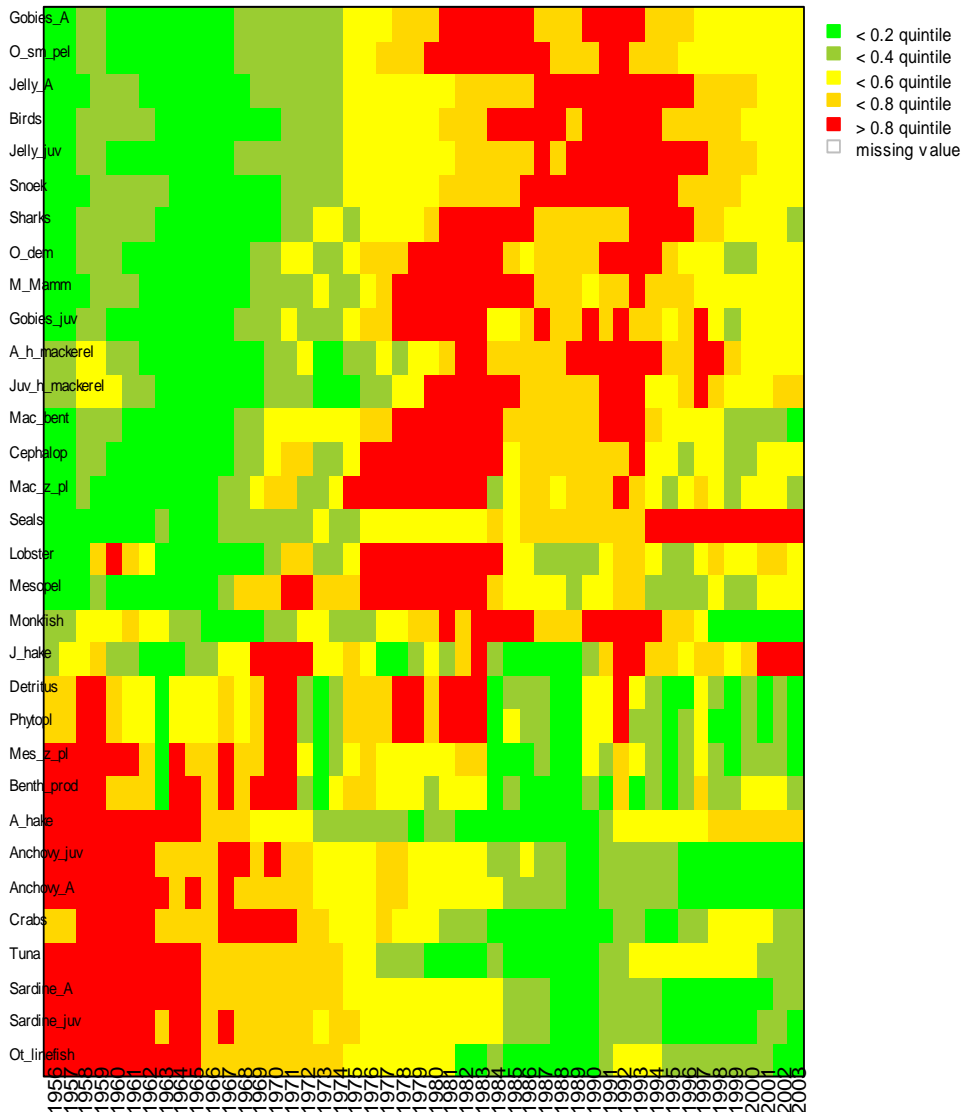


PC1 (38%):
 +Demersal
 trawl effort,
 hake catch



Variables (sorted by their loading on the 1st PC)

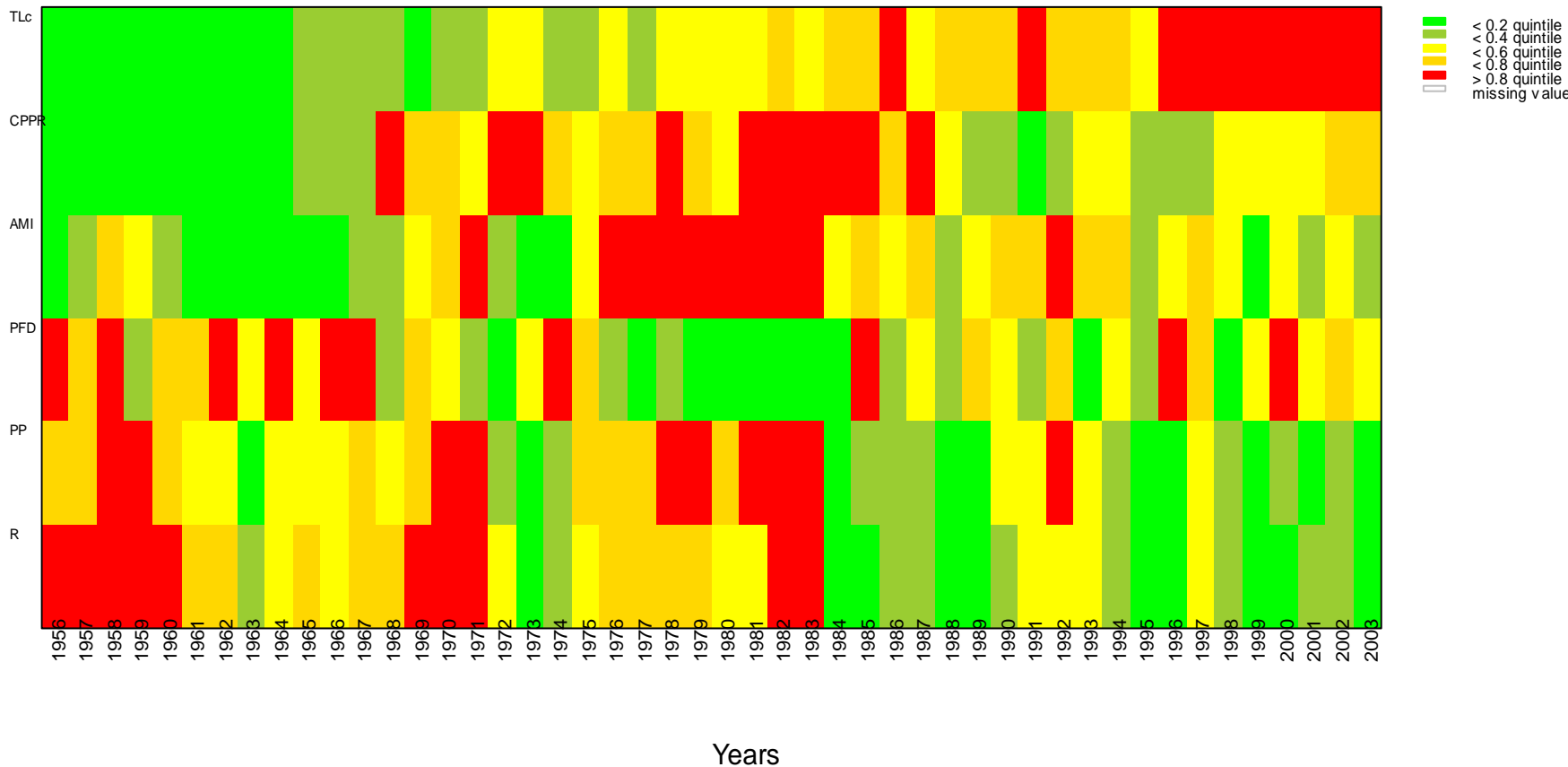
Traffic Light Plot



Network analysis indices

Traffic Light Plot

Variables (sorted by their loading)



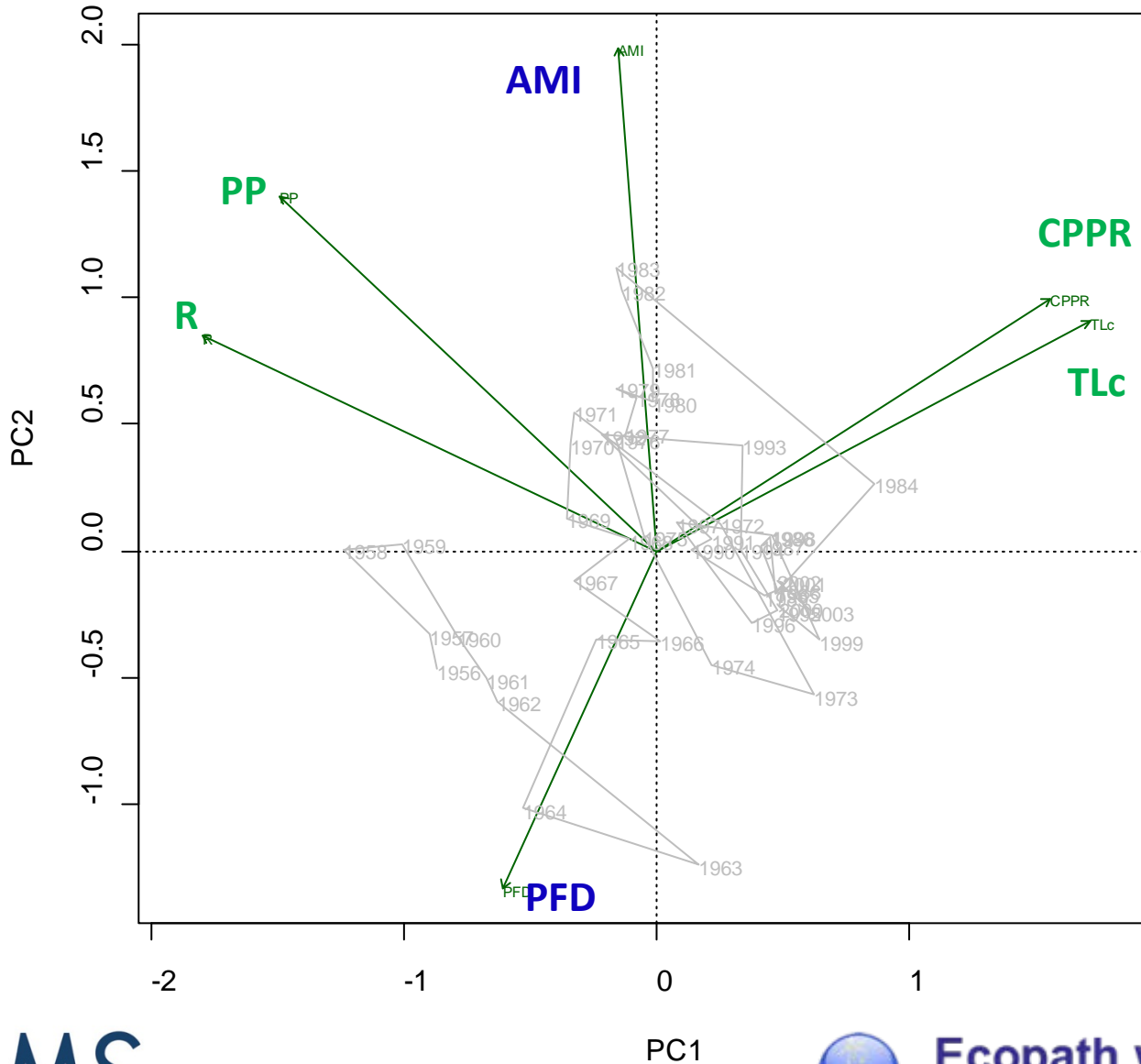
R = Resilience – distribution of energy flow among the pathways (Ulanowicz 2004)

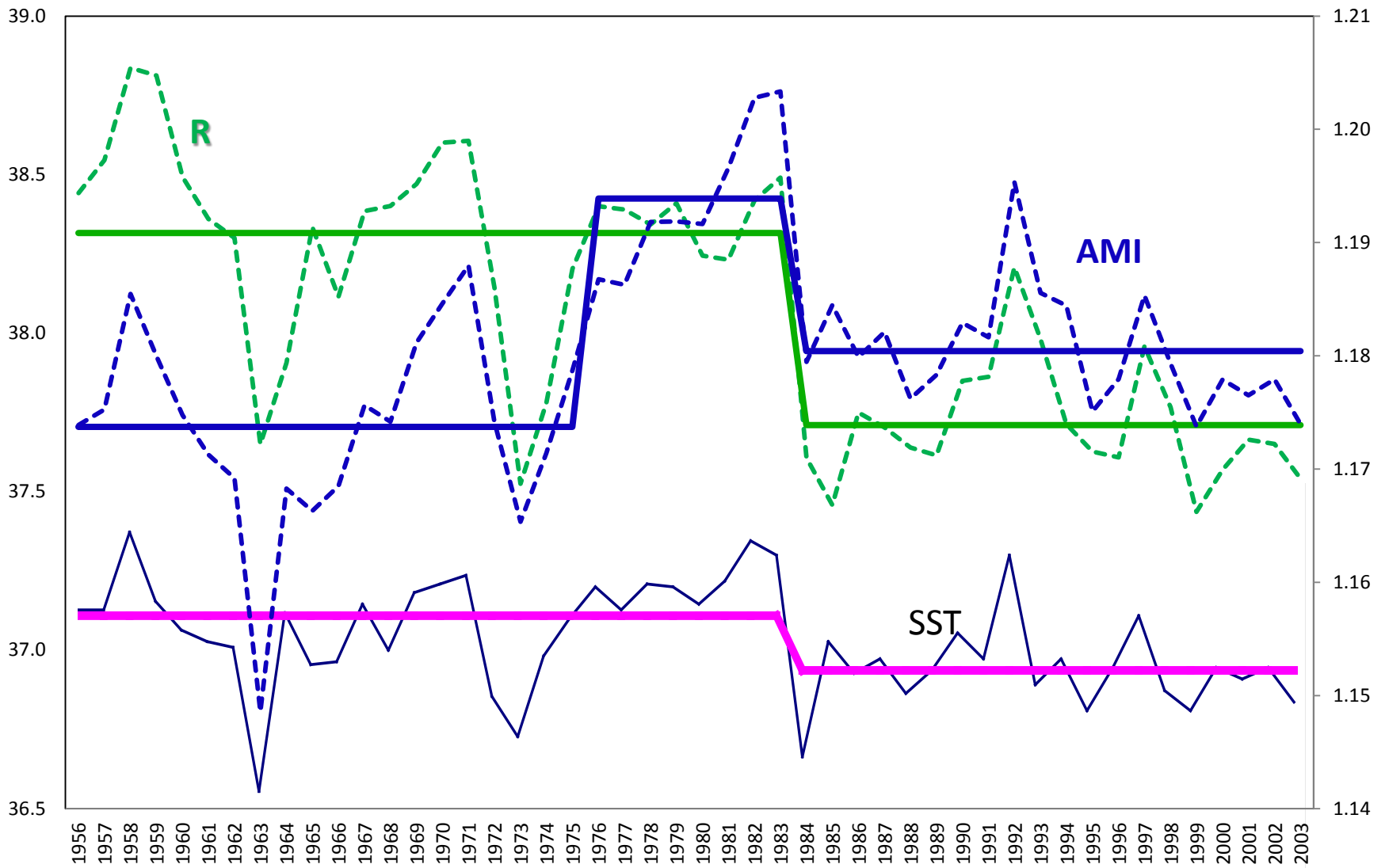
AMI = Average Mutual Information – measures organization of flows (Ulanowicz et al 1997)

Biplot with time trajectory

PC1 (60%):
+ TLc/CPPR
- R, PP

PC2 (25%):
+AMI
- PFD





R = Resilience – distribution of energy flow among the pathways (Ulanowicz 2004)

AMI = Average Mutual Information – measures organization of flows (Ulanowicz et al 1997)

Summary

- Development in **3 periods**, <early 1970s, mid 19780s-mid1980s, >mid-1980s
- fishing and SST combined have **reorganised** the ecosystem
- 1972 and 1984 **Benguela Niño** evident in the R and AMI due to ↑ fishing and the lack of primary production in those years
- Large fishing <mid-1970s combined with the Benguela Niño in 1972 **changed the internal structure of the ecosystem** (↑ AMI)
- **1984 ↓ AMI** due to the increase in **gobies/jellies** that have taken over the anchovy/sardine niche
- **↓resilience** (diversity of flows among the different pathways) from the start of the fishery to the **1984 Benguela Niño**, when abruptly changed to a new state, with **lower energy distribution through both the demersal system and the sardine/anchovy section** of the pelagic system
- System should now be managed as one with **↓ redundancy**, thus **reduced fishing pressure**.