Are general mechanisms found behind regime-shifts across marine ecosystems?

Niiranen, S.[1,2], Blenckner, T.[1] and Biggs, R.[3]

[1]Baltic Nest Institute, Stockholm Resilience Centre, Stockholm University

[2]Department of Systems Ecology, Stockholm University

[3]Stockholm Resilience Centre, Stockholm University

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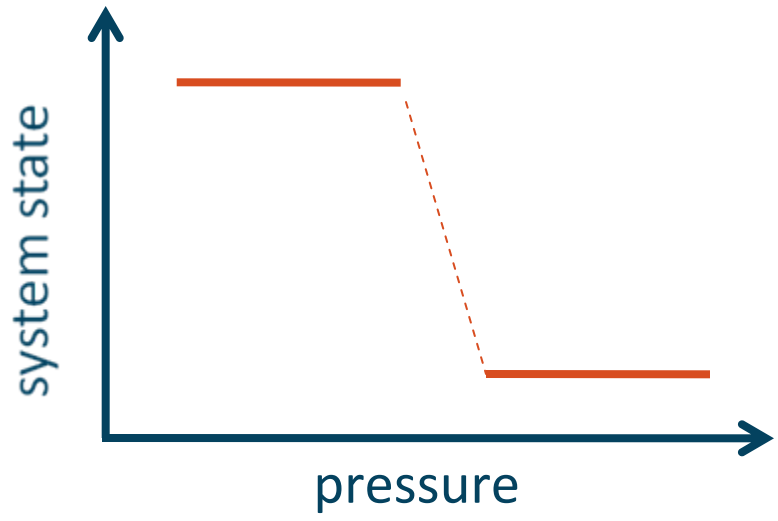
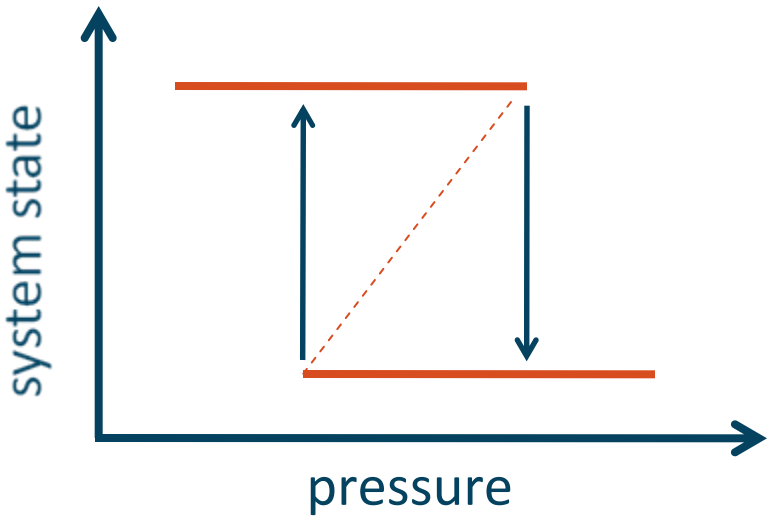
What is an ecosystem regime shift?

1. Sudden (non-linear) response

2. affects several TLs

3. changes system function → hysteresis





Importance

- Shifts affect global ecological and economical resources
  - e.g. unexpected changes in commercial fish stocks induced by marine regime shifts
- Changes in ecosystem state affect success of different management options

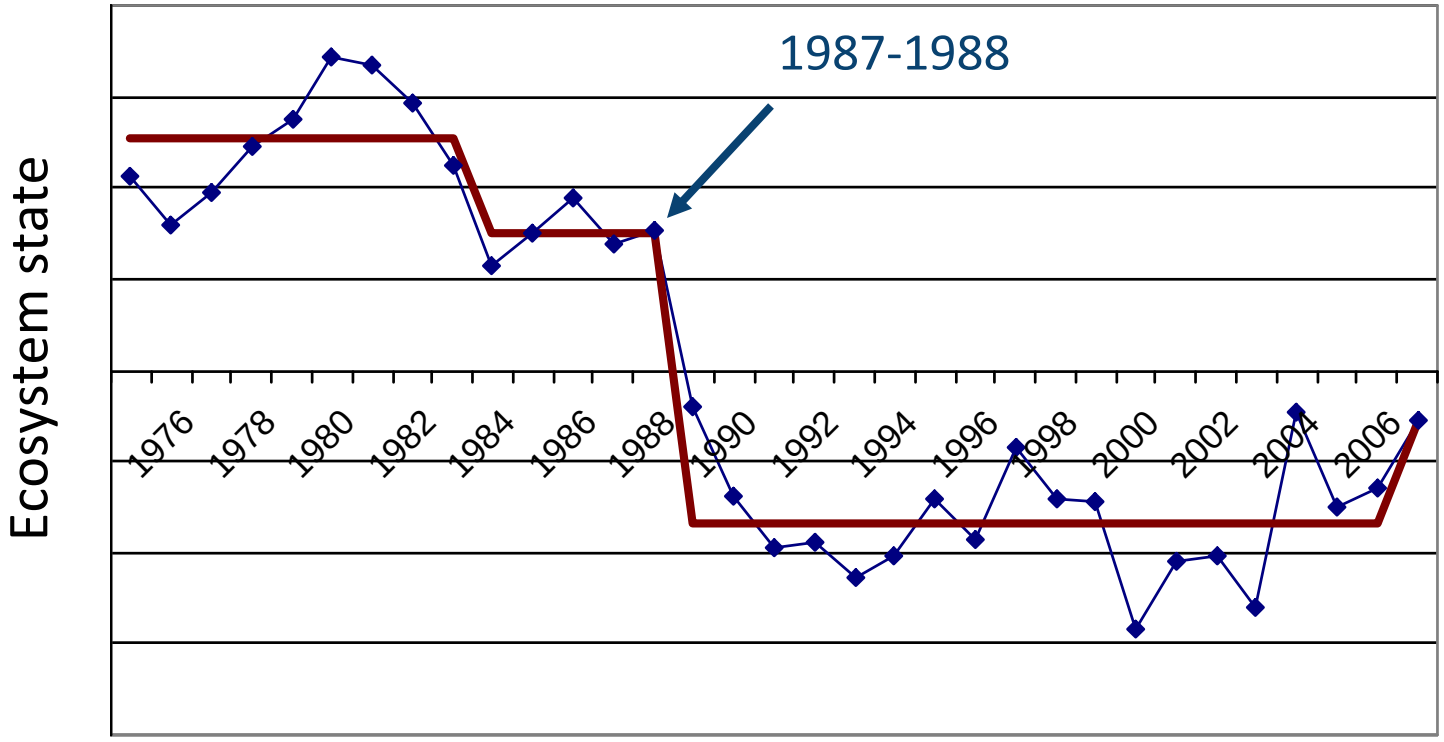
➢ Can carefully targeted ecosystem based management mitigate/prevent climate driven shifts?

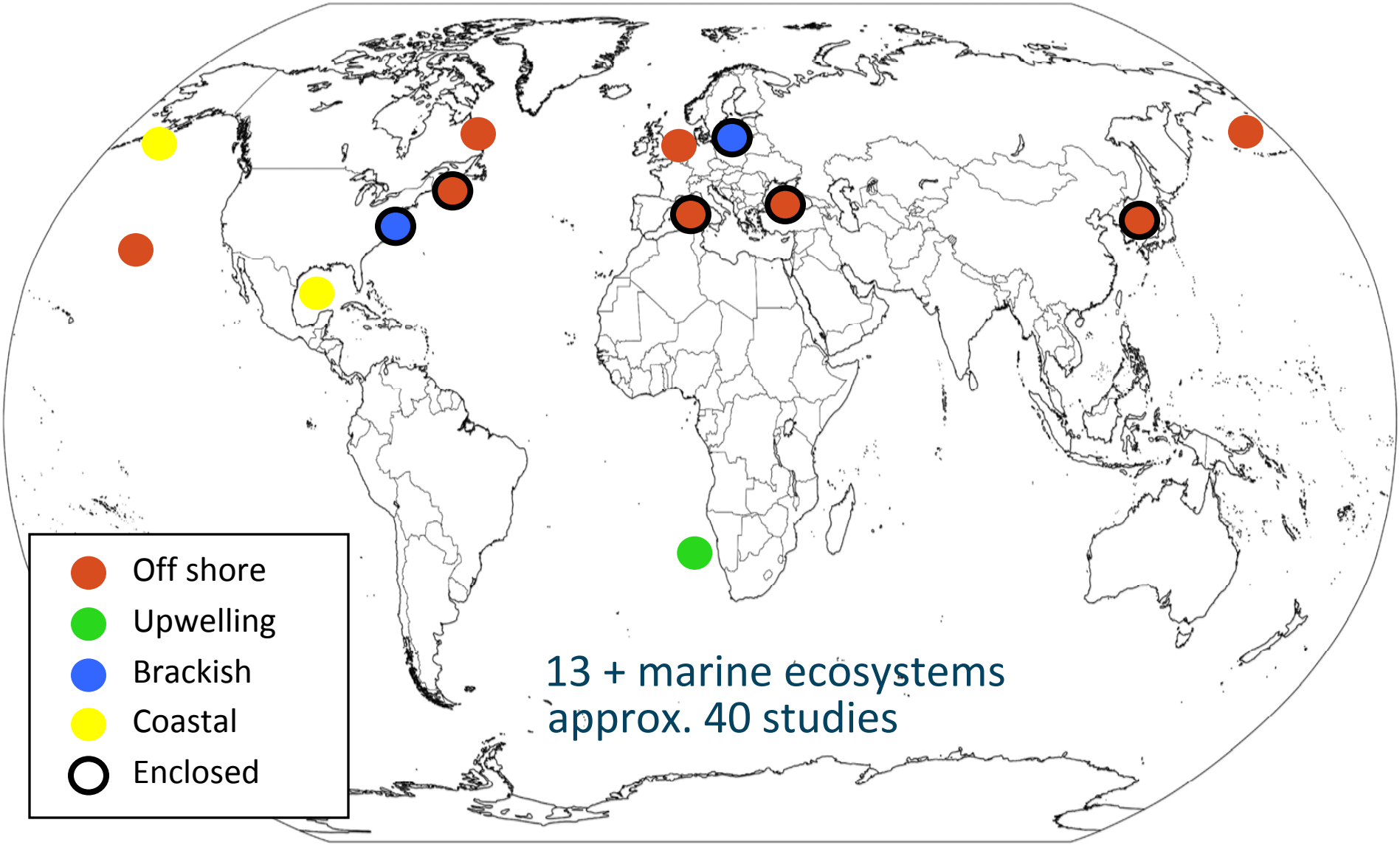
Marine regime shift detection

- Detection methods used:
  - Changes in principal components (PCA)
  - Sequential- t-test analysis (STARS, Rodionov 2004)
  - Correlation analysis and F-test
  - Moving window boundary analysis
  - Chronological clustering
  - Change in means, t-test
  - Inverse modelling

➢ Answers the questions when and what.

Regime shift in the Central Baltic Proper





Map modified from: http://www.world-map-interactive.info/images/world-map/world-pics/world-map.gif

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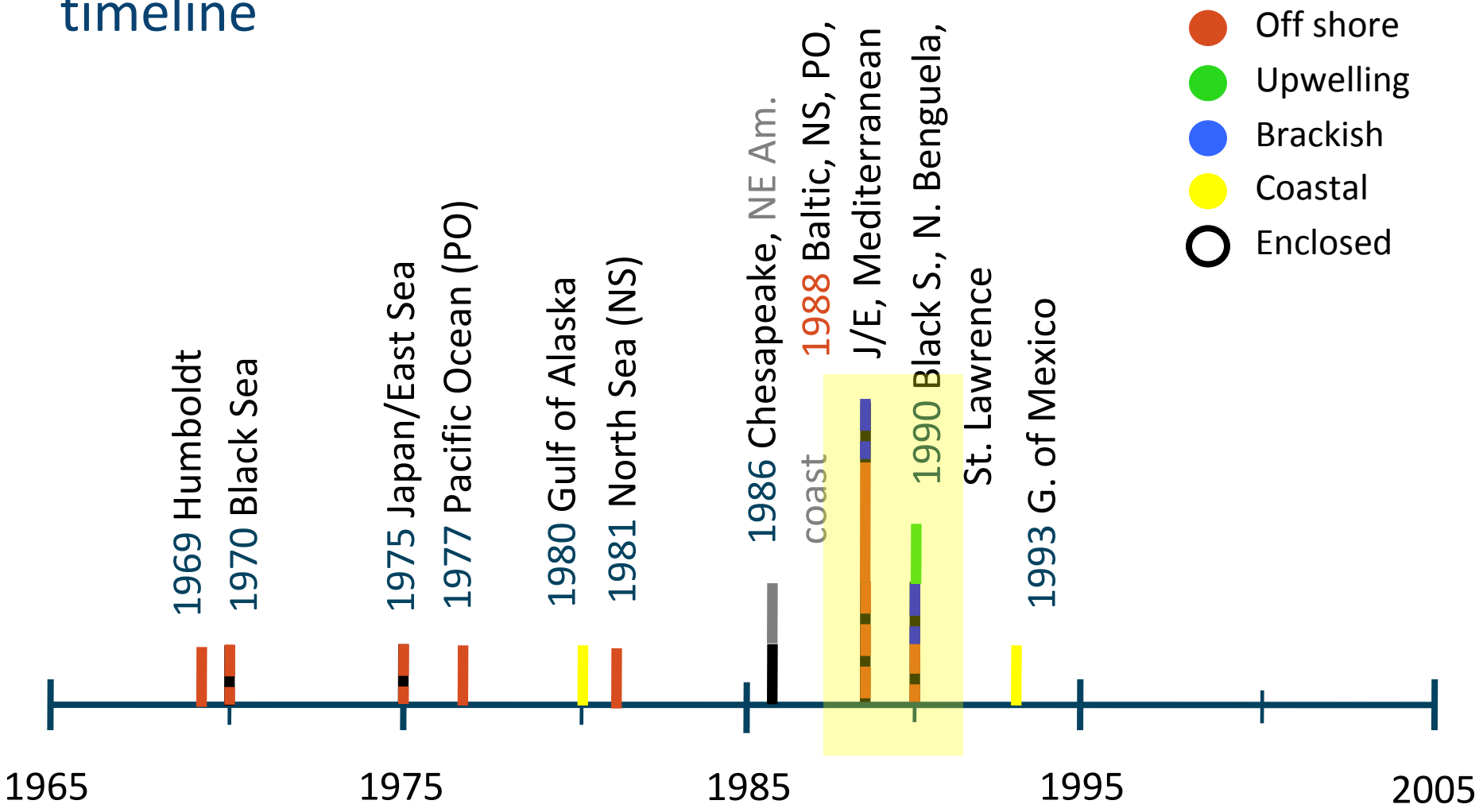
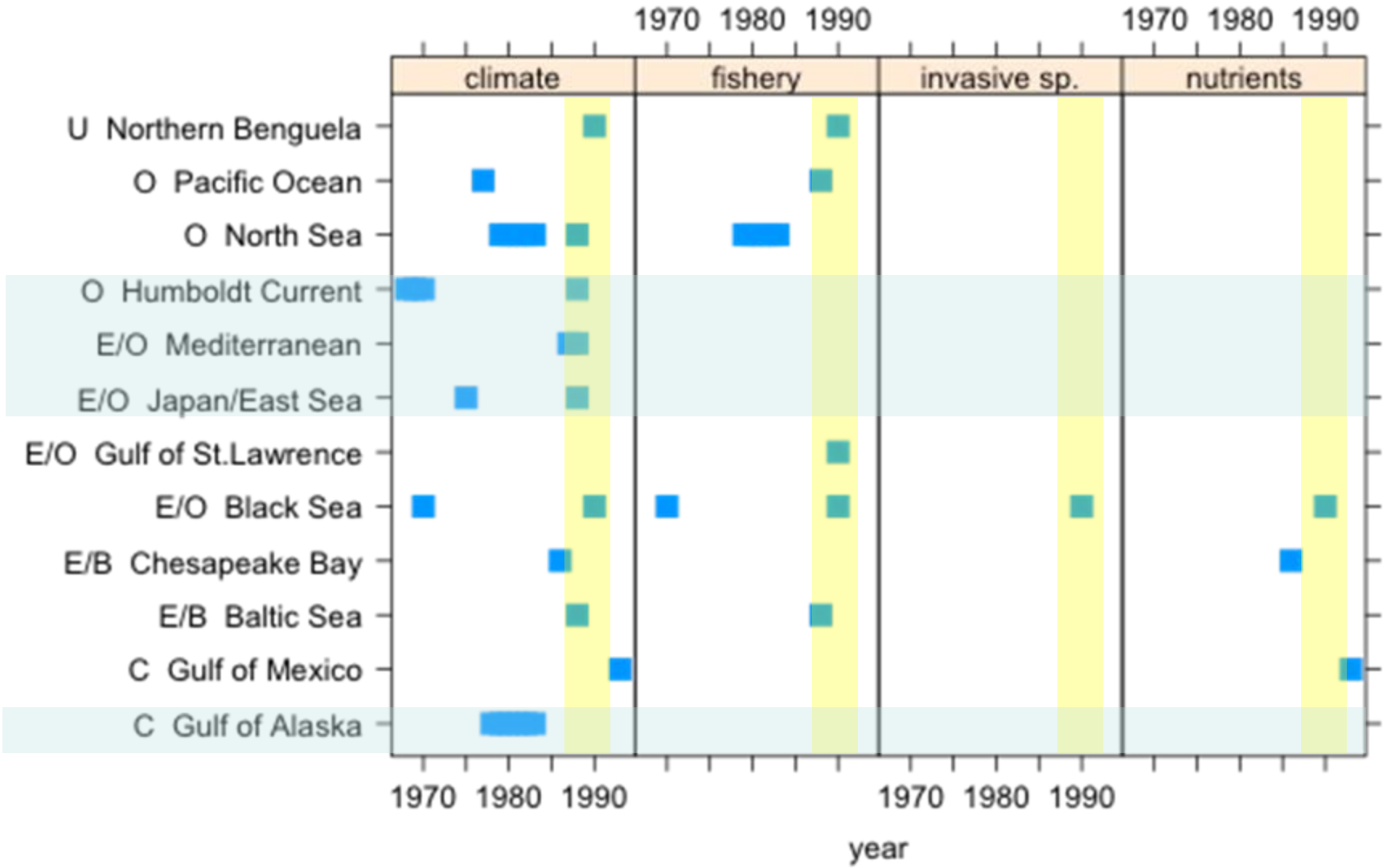
timeline


Off shore
Upwelling
Brackish
Coastal
Enclosed
1969 Humboldt
1970 Black Sea
1975 Japan/East Sea
1977 Pacific Ocean (PO)
1980 Gulf of Alaska
1981 North Sea (NS)
1986 Chesapeake, NE Am.
1988 Baltic, NS, PO, coast
J/E, Mediterranean
1990 Black S., N. Benguela,
St. Lawrence
1993 G. of Mexico
1965
1975
1985
1995
2005


1970 1980 1990
1970 1980 1990
climate
fishery
invasive sp.
nutrients
U Northern Benguela
O Pacific Ocean
O North Sea
O Humboldt Current
E/O Mediterranean
E/O Japan/East Sea
E/O Gulf of St.Lawrence
E/O Black Sea
E/B Chesapeake Bay
E/B Baltic Sea
C Gulf of Mexico
C Gulf of Alaska
1970 1980 1990
1970 1980 1990
year

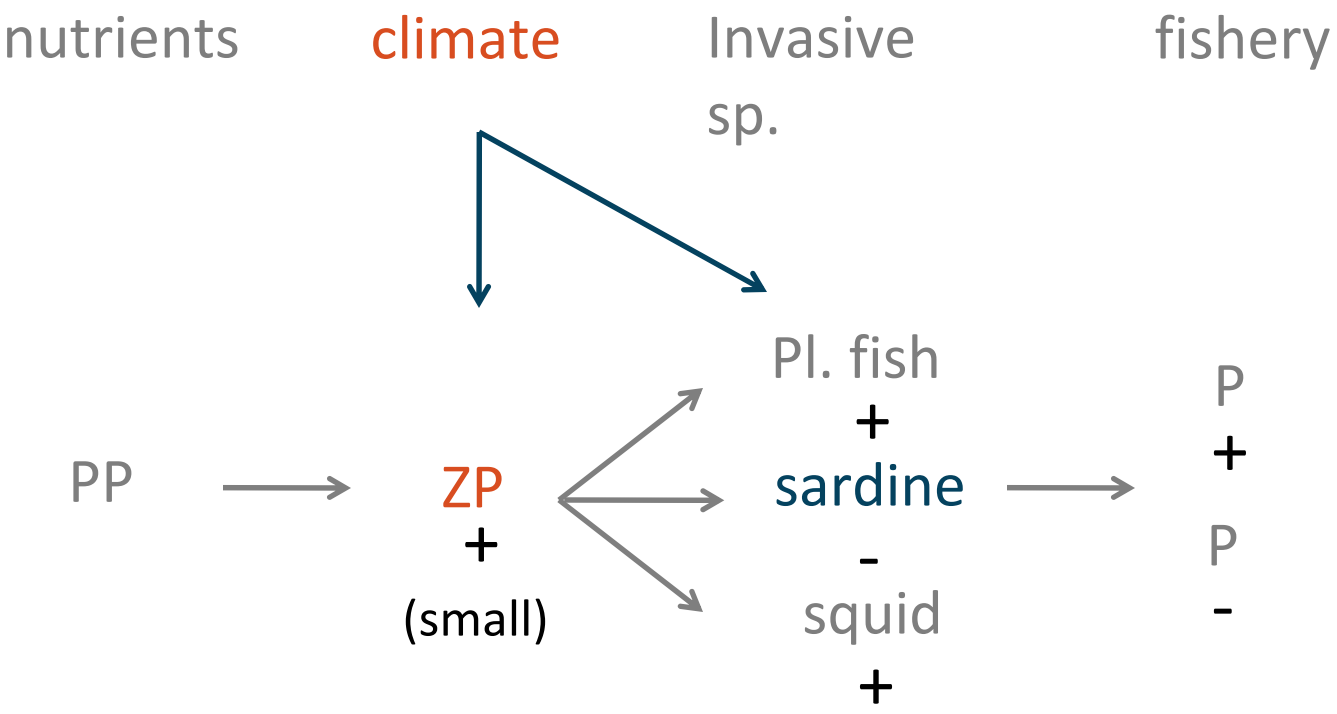
Feedback mechanisms

- Mechanisms either related to trophic cascades
  - competition (incl. invasive species) (many systems)
  - predator-prey relations (many systems)
  - inverse predation (Baltic Sea)
  - schooling (within TL) (*Cury and Shannon, 2004*)

- And/Or feedback to the environment
  - Eutrophication induced hypoxia (e.g. Baltic Sea, Black Sea, Chesapeake Bay)

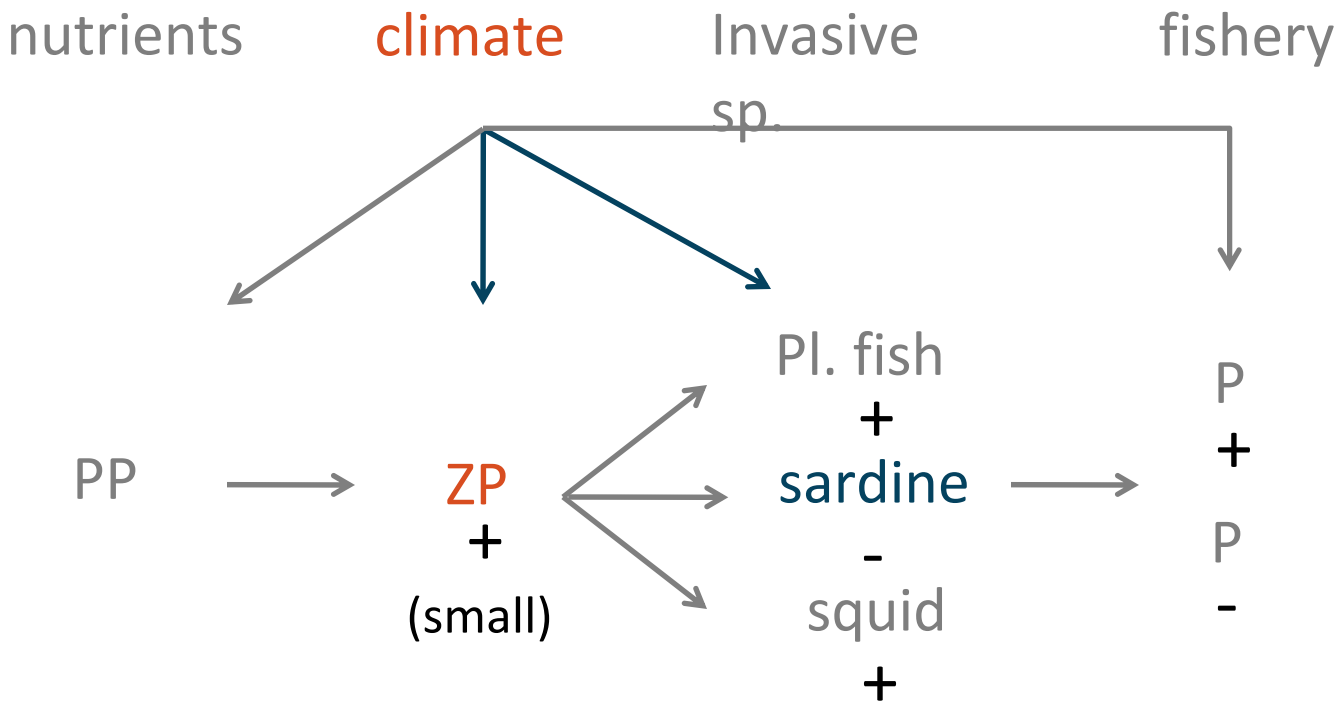
    → internal nutrient loading
    → decreased fish reproduction

Japan/East Sea (1988/-89)



Based on *Tian et al. (2006 and 2008), Zhang et al. (2007)*

Japan/East Sea (1988/-89)



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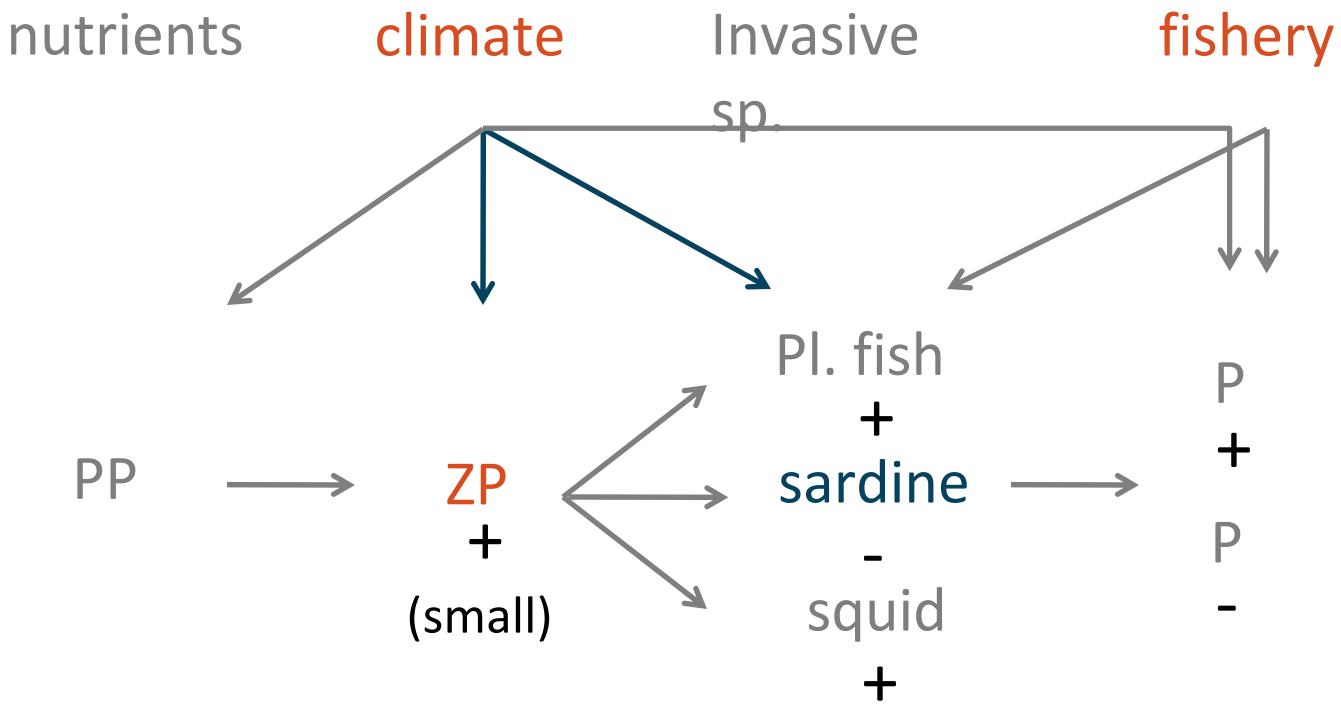

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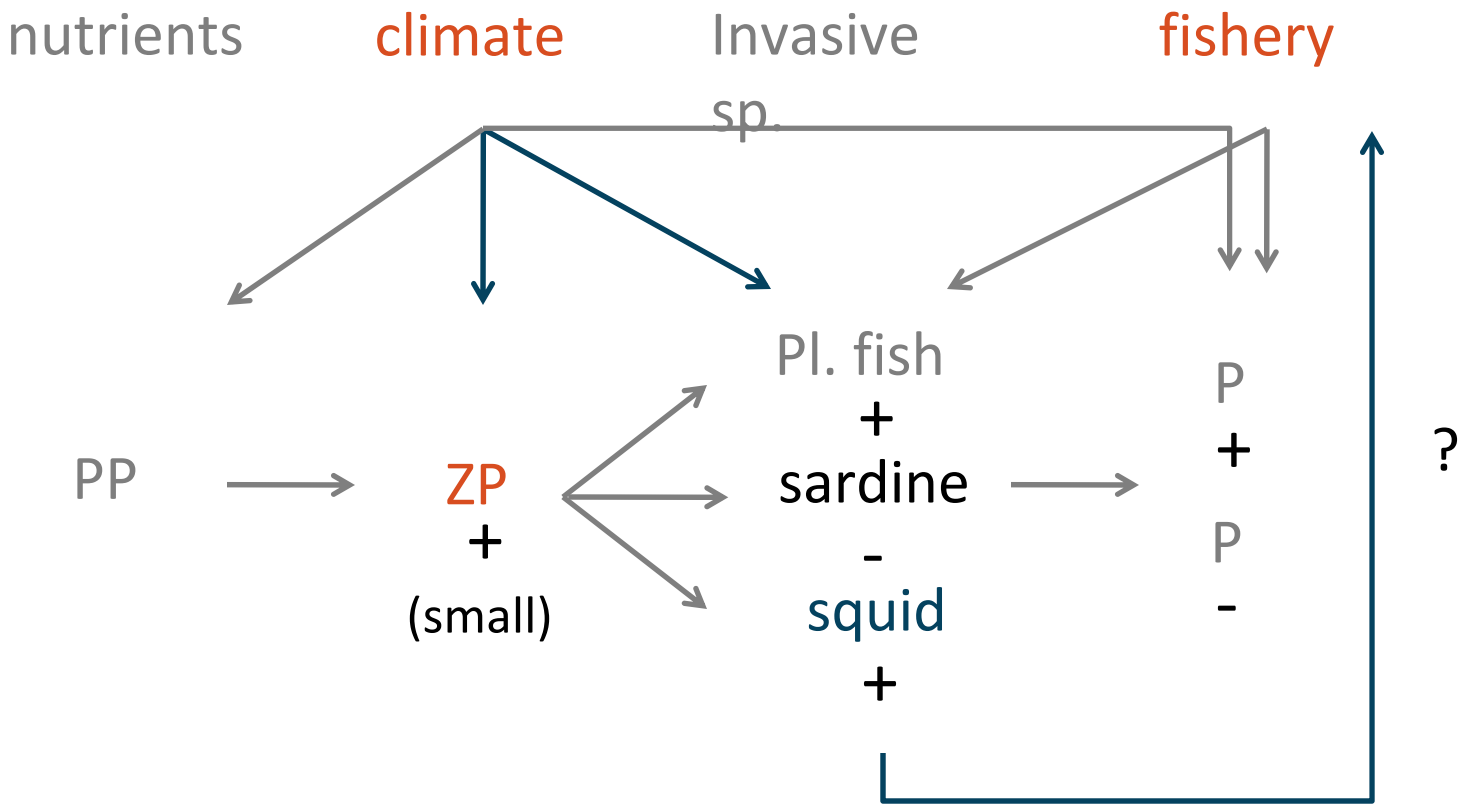

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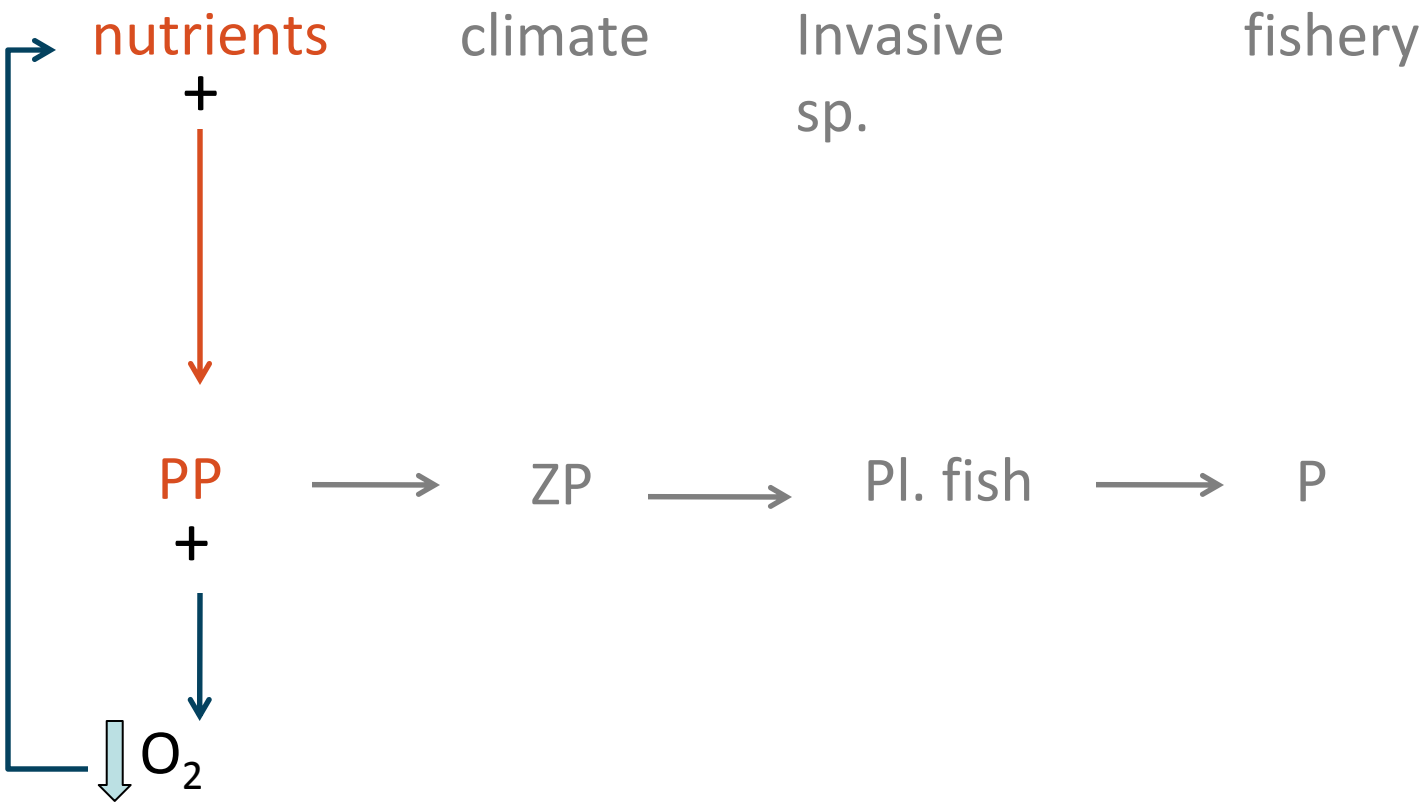
Baltic Sea (late 1980s)



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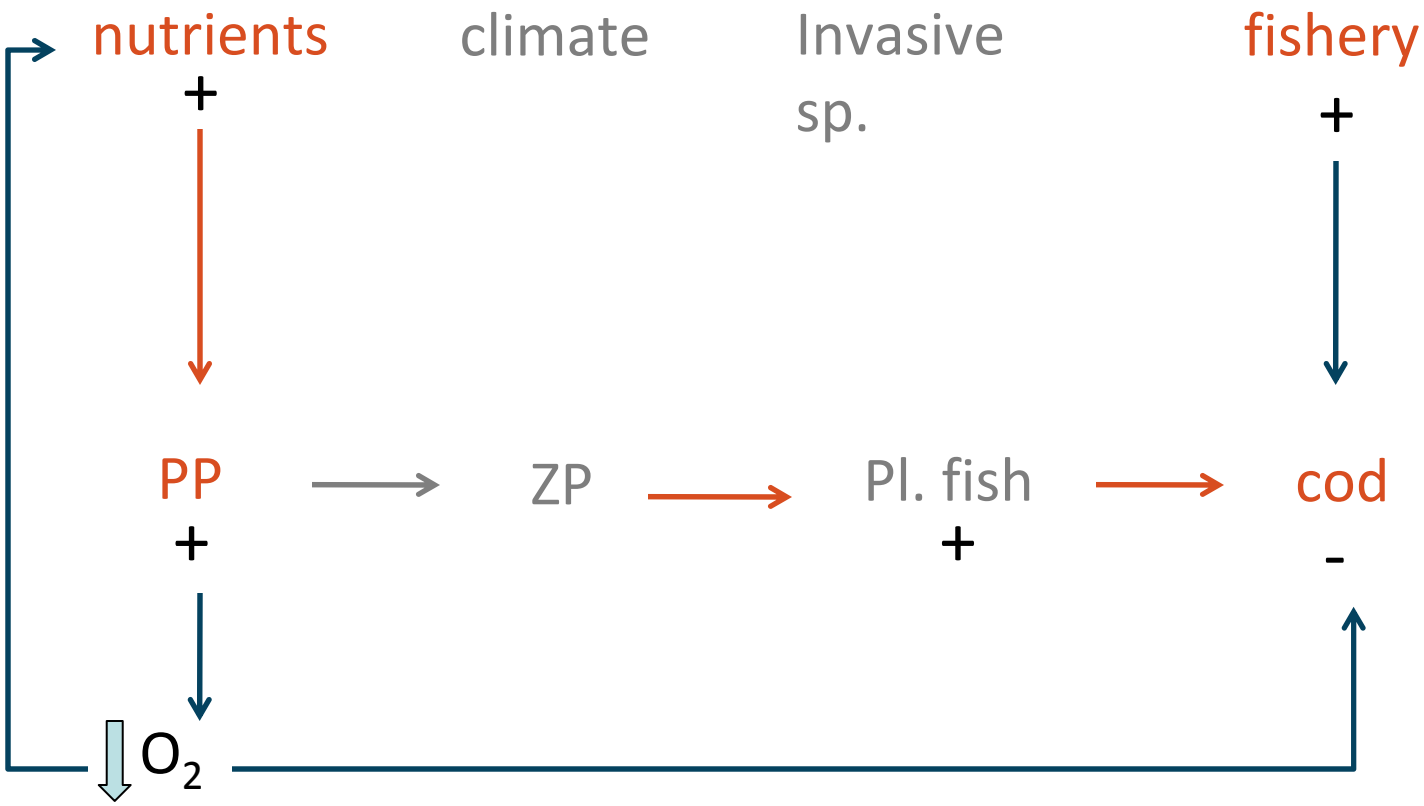

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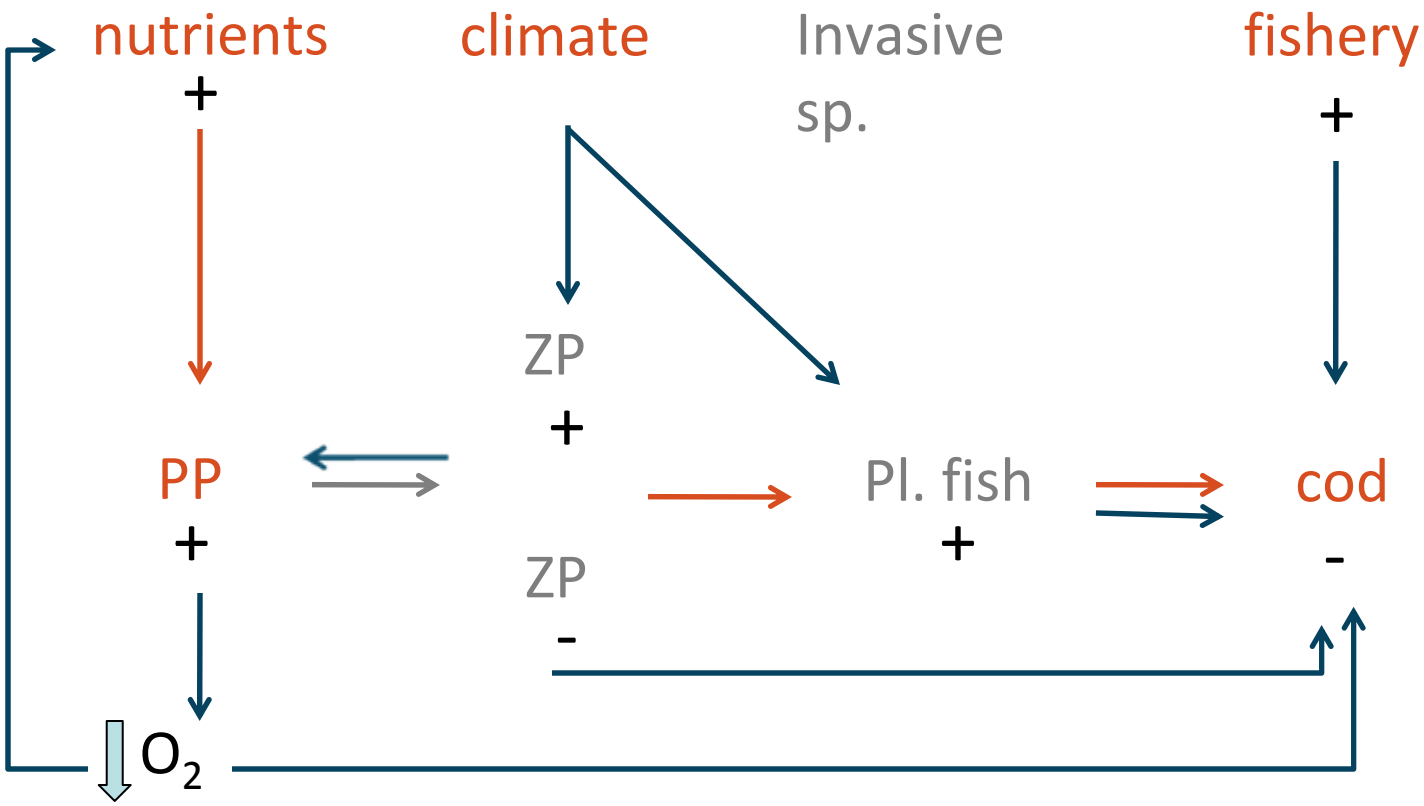

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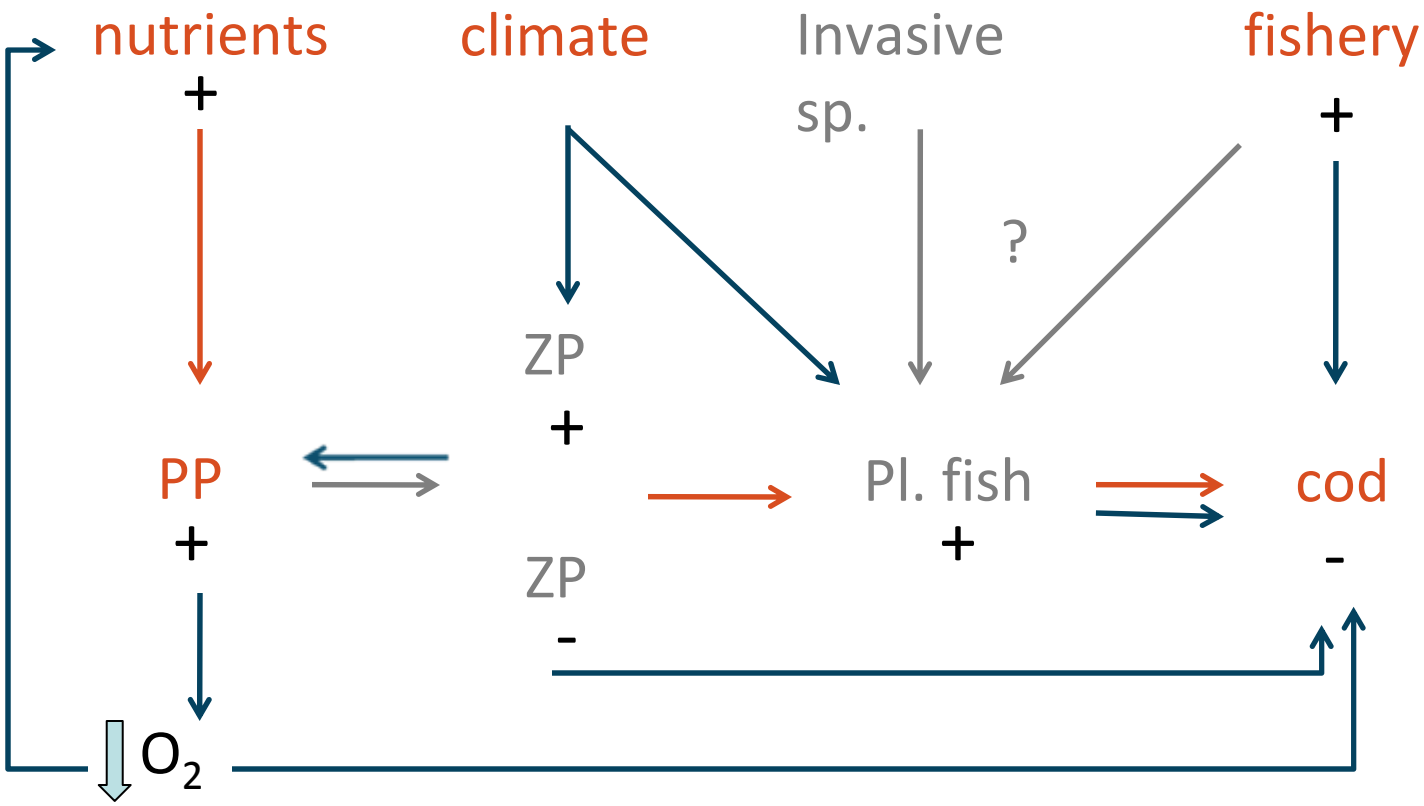
Baltic Sea (late 1980s)



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Multiple drivers

- Regarding CC important to know if multiple drivers are:

  1) required to cause change
  2) cause more severe change
  3) erode system resilience

- Difficult to identify the effect of a single driver as ~~"1+1 = 2".~~

- Comparative systems with similar climate, different response (e.g. Japan/East Sea, Benguela)
- MPAs

Conclusions

- Multiple drivers, but late 1980s climate induced shift detected widely.
- Now what and mostly when are addressed.

Next how!

- ecosystem indices and their shifts (e.g. *Tian et al. 2006*)
- Combination of modelling, statistics and experiments needed

Thank you

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www.baltex-research.eu/ecosupport

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e-mail: susa.niiranen@stockholmresilience.su.se
web: www.stockholmresilience.su.se