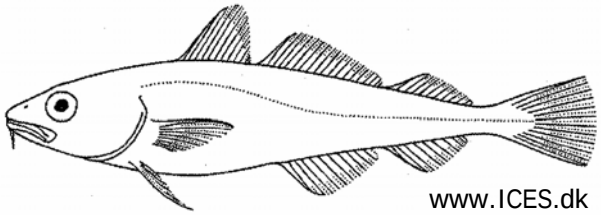
Impact of climate change on North Sea Atlantic cod

Modelling larval survival

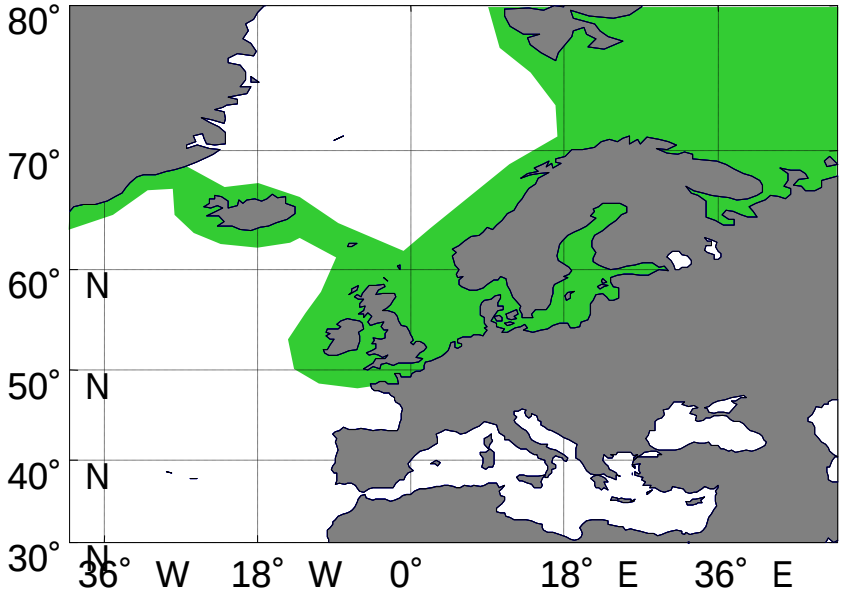
Ute Daewel, Corinna Schrum, Dhanya Pushpadas

UNIVERSITY OF BERGEN

Key Species → Atlantic cod (*Gadus morhua*)



Distribution



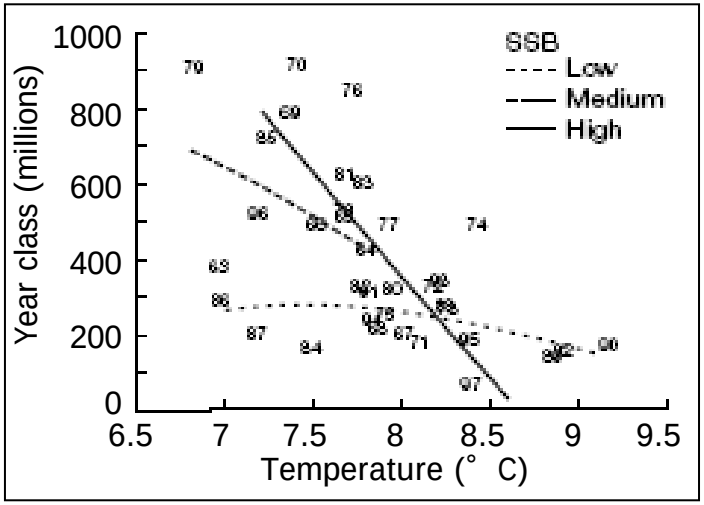
Family Gadidae

- $Length_{max}$= 150 cm
- Age_{max}=25 yrs
- Pelagic eggs & larvae
- Demersal adults
- Zooplanktivorous larvae
- Top predator

Cod recruitment is linked to temperature

(O'Brien et al. 2000)

- low T → high recruitment
- Depending on SSB



ECOSMO - IBM

ECOSMO

3-D hydrodynamic Model
(Schrum et al. 2000)

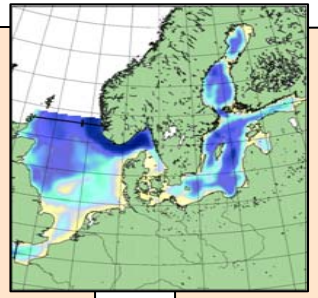
3D-primitive equation model

horiz. resolution 10 km

3-D trans,light, turb, T

NPZD module
(Schrum et al. 2006)

- 3 nutrient cycles (N,P,Si)
- 2 phytoplankton groups
  (diatoms, flaggelates)
- 2 zooplankton groups
  (herbivor., omnivor.)



Spatially-explicit IBM

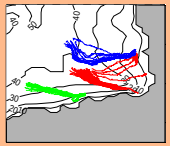
3-D hydrodynamic Model

3-D trans, turb

light, turb, T

3d-location

Transport module
Lagrangian
advection
& diffusion



Mechanistic IBM
(eggs & larvae)

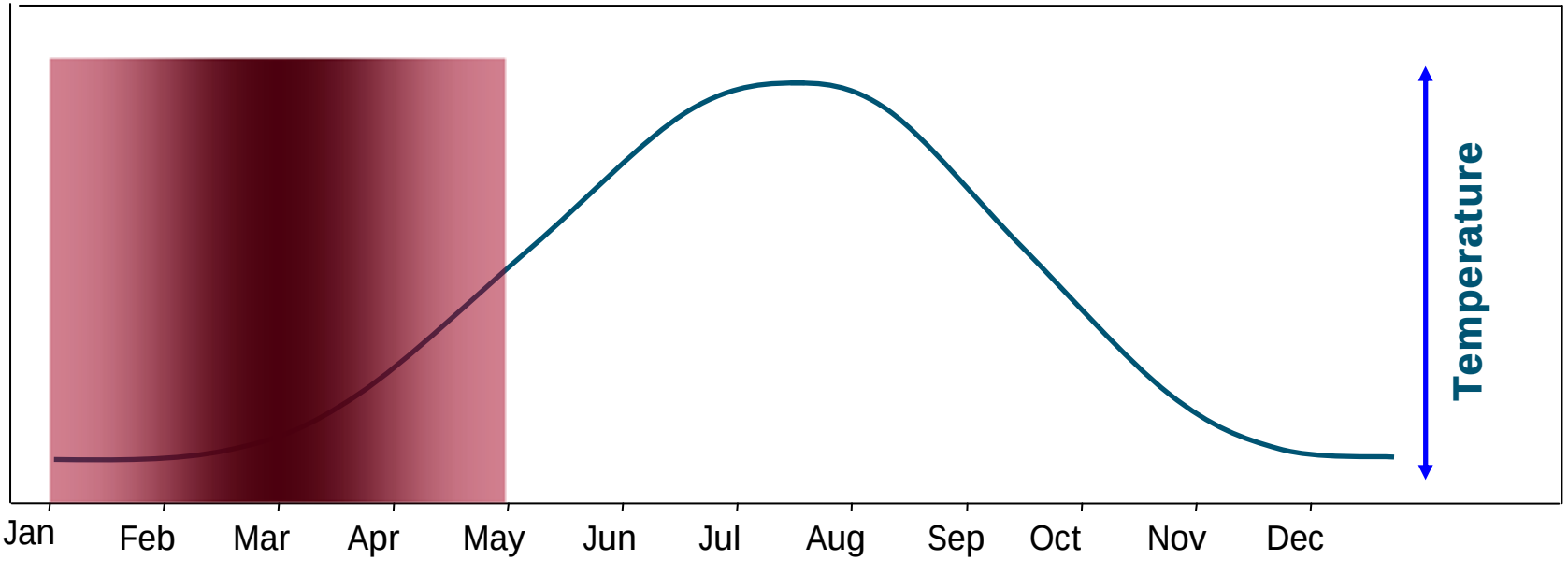
zooplankton biomass

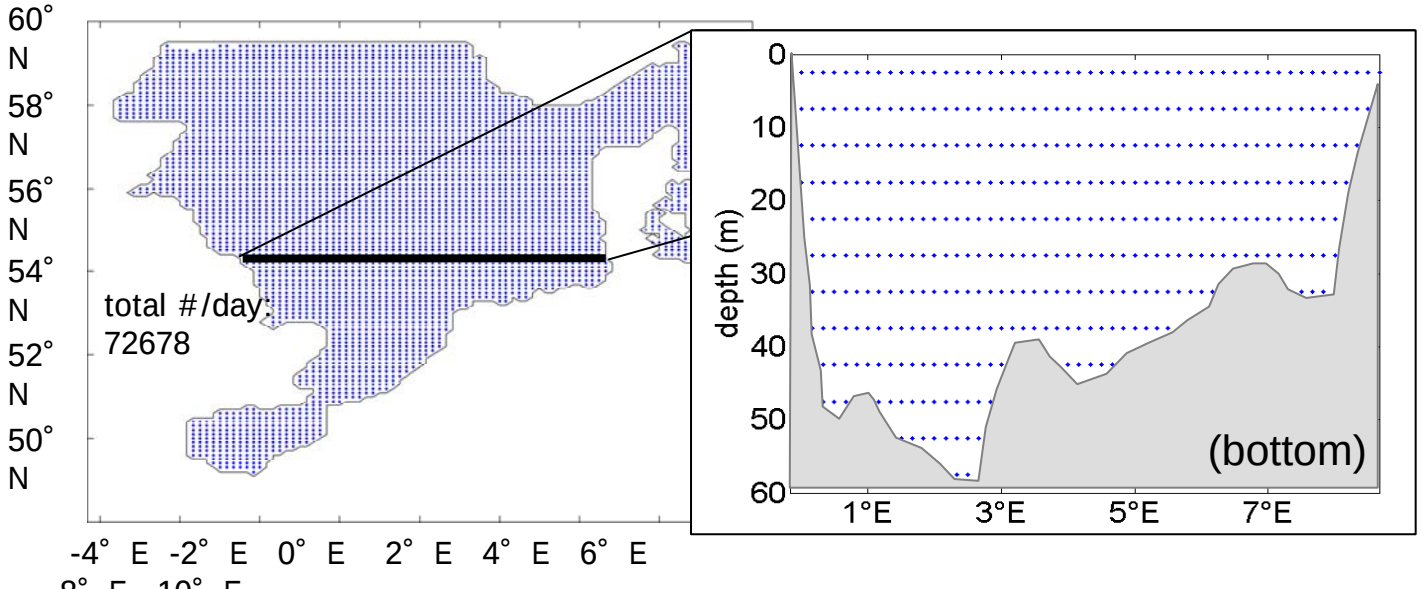
prey

Particle release

Atlantic cod (*Gadus morhua*)

www.fishlarvae.com





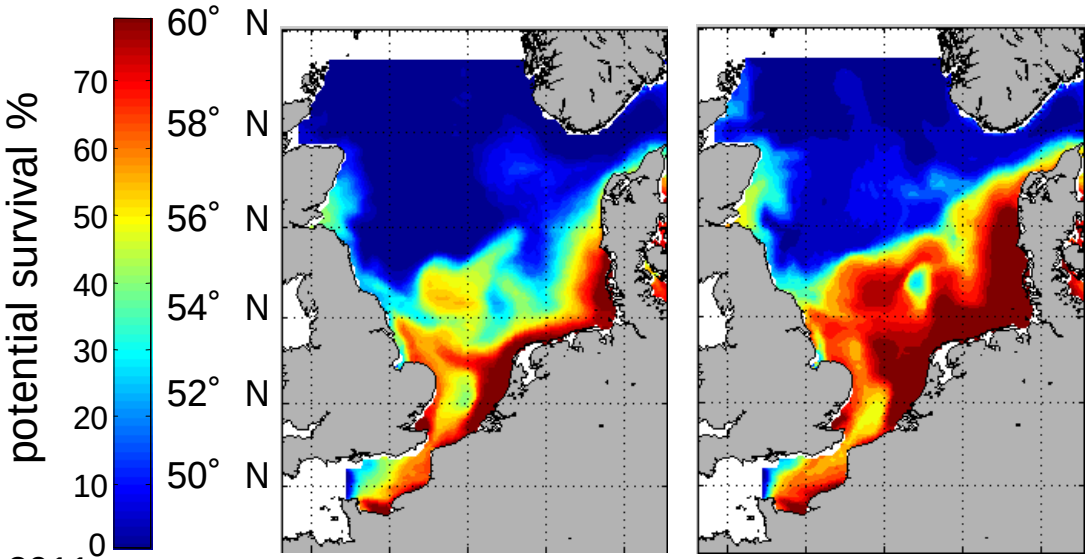
Uncertainties - Impact of advection scheme

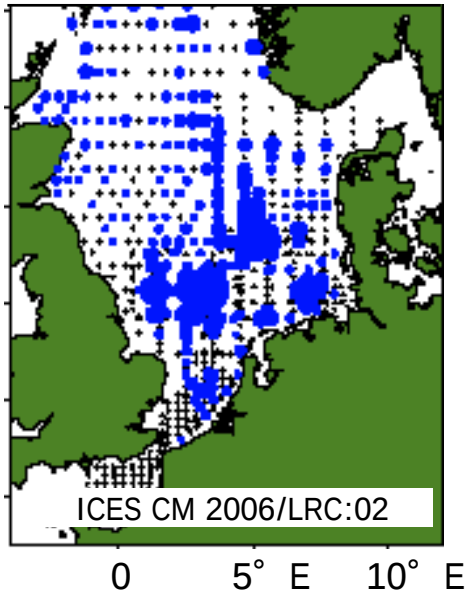
areas supporting potential survival compared to observations

Cod

UPW

Averaged values January-April





Daewel et al. 2011

Scenario experiments

I. Long term hindcast 1960-2008

- Assess the aplicability of the approach
- assess past climate change impacts on PLS
- Identify potential indicators

II. Sensitivity runs: 1990-1996

→ Tair, wind, prey

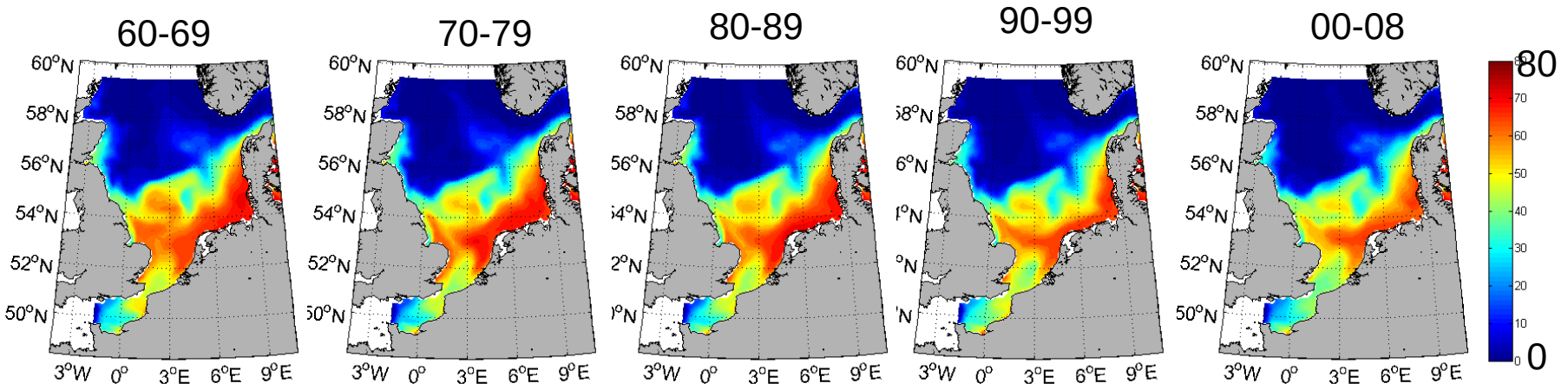
→ Identify the importance of the different stressors

III. Perform climate projections with 2 GCM-ESM (IPSL, NorESM)

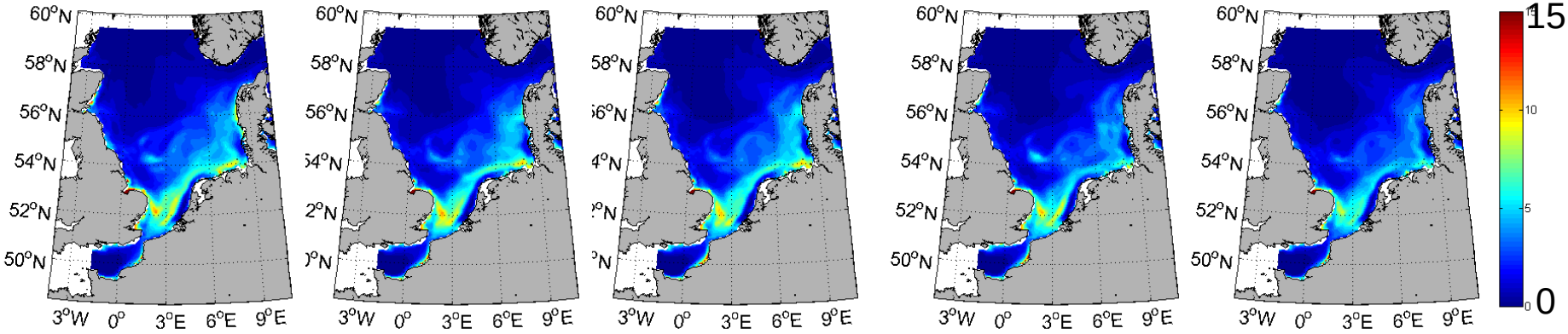
- Assess potential uncertainties
- Discuss the aplicability of the approach for future projections

Long term hindcast: results

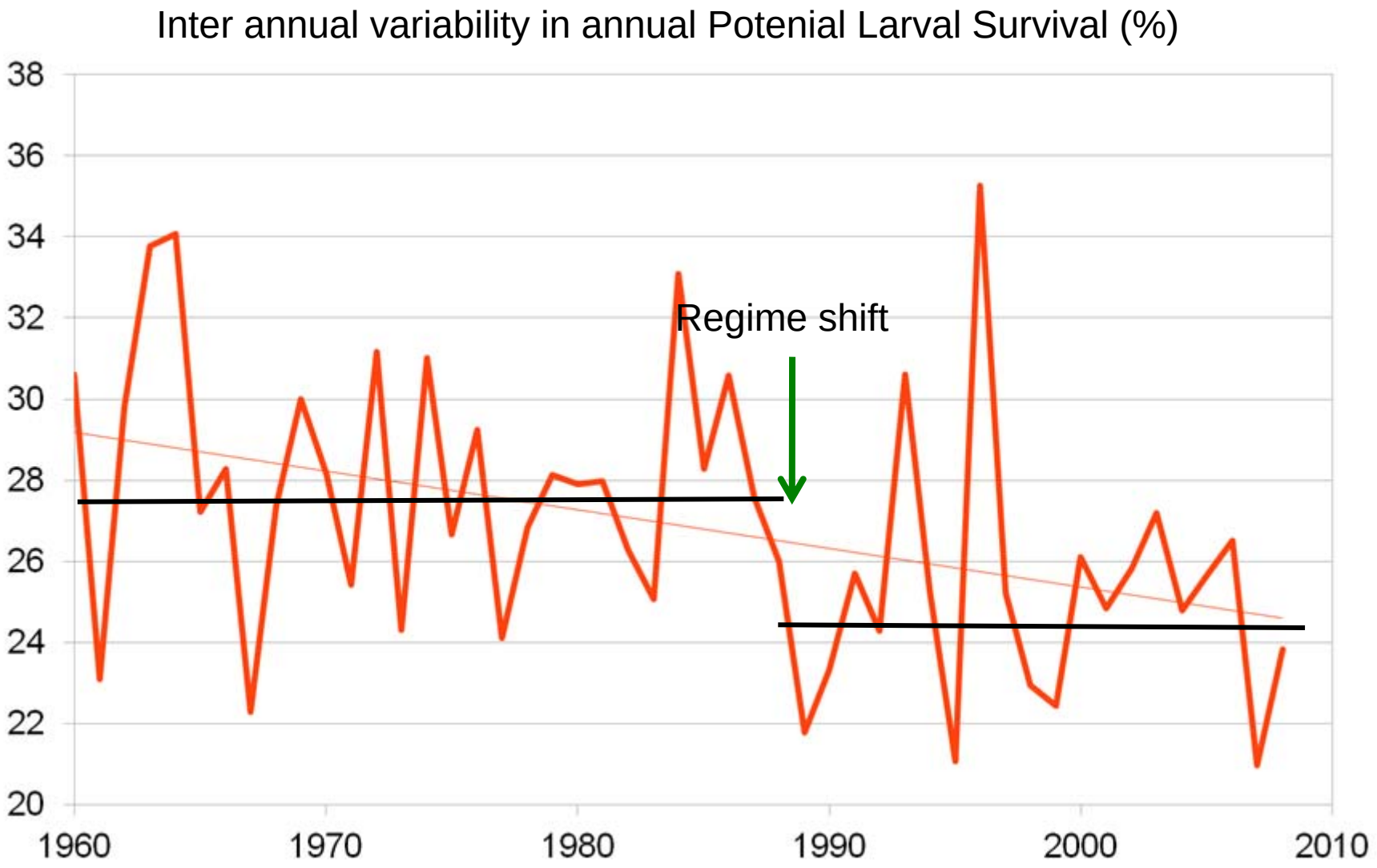
Potential larval survival (%) decadal averages



Average larval concentration (No/gb*m) <20mm March-July



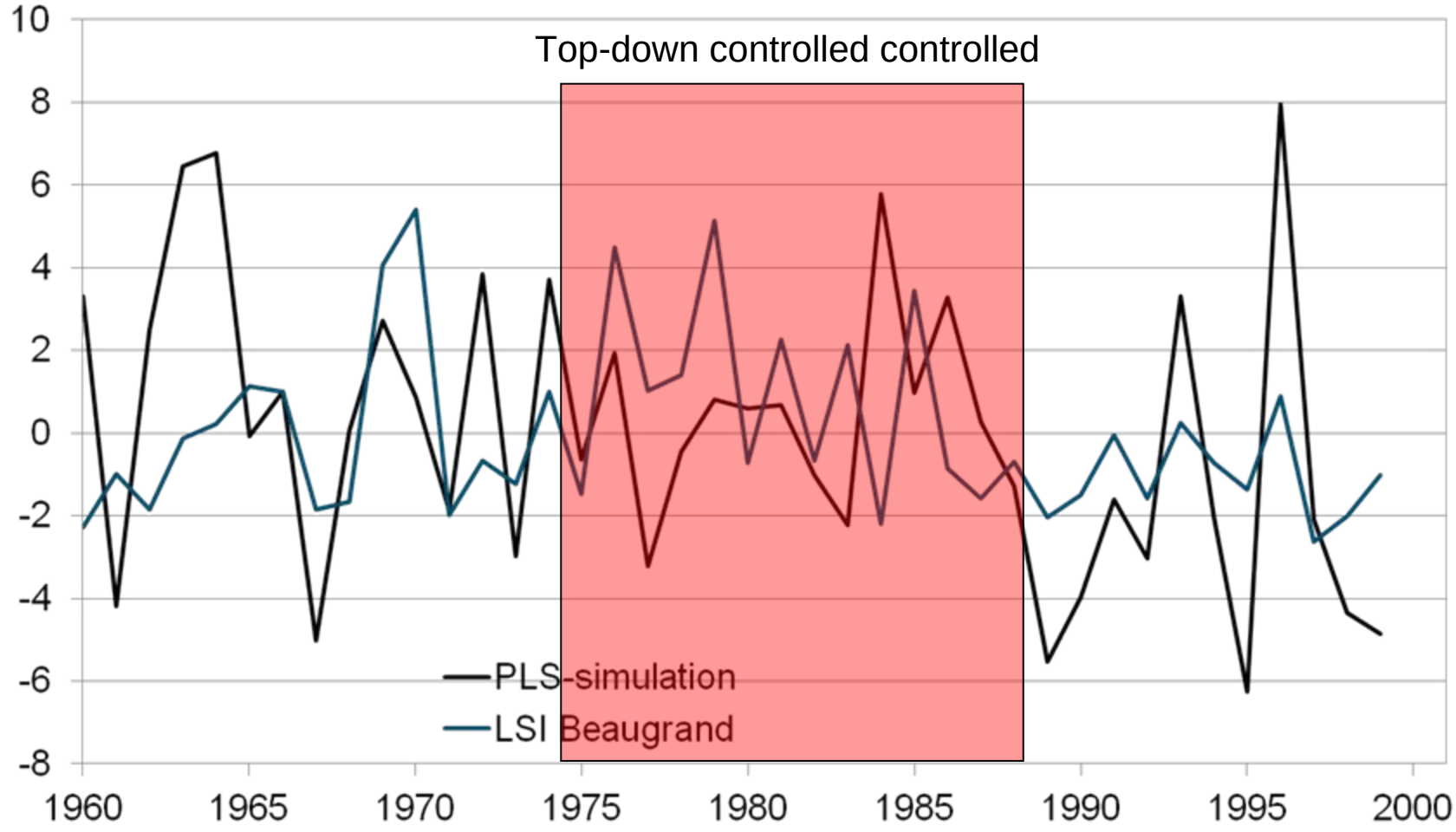
Long term hindcast: results



Long term hindcast: results

Difference to mean PLS: Potenial Larval Survival

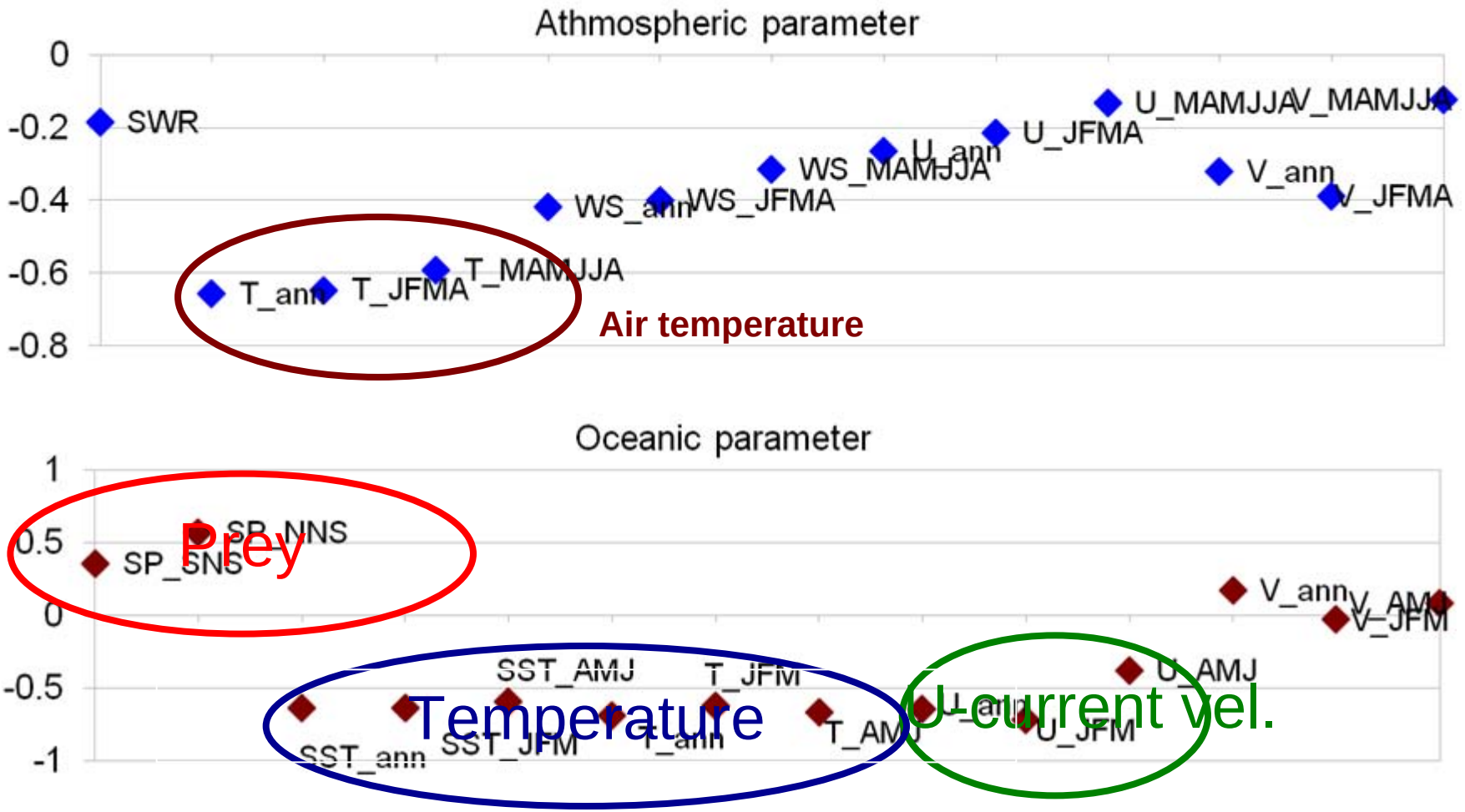
LSI: larval survival index redrawn from Beaugrand et al. 2003



Long term interactions

Correllation of annual PLS to environmental variables

Averaged over different time scales



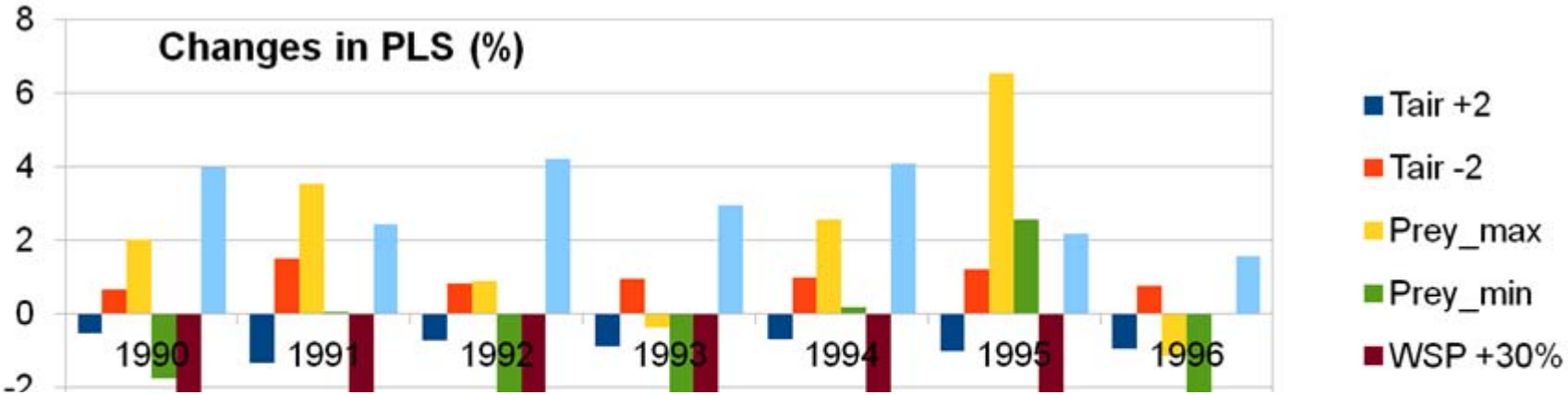
Scenario experiments

Scenarios for 1990-1996

I.Changed air-temperature by +2 degC and -2 degC

II.Adapt max prey (1967) and min prey (1960) (from secondary prod.)

III.Changed wind speed by +30% and -30%



-strongest and consistent impact of changes in wind speed (neg. corellated)

-strong but variable impacts of the prey field → interactions with other parameters

-Lowest impacts from changes in air temperature → air temperature is a proxy

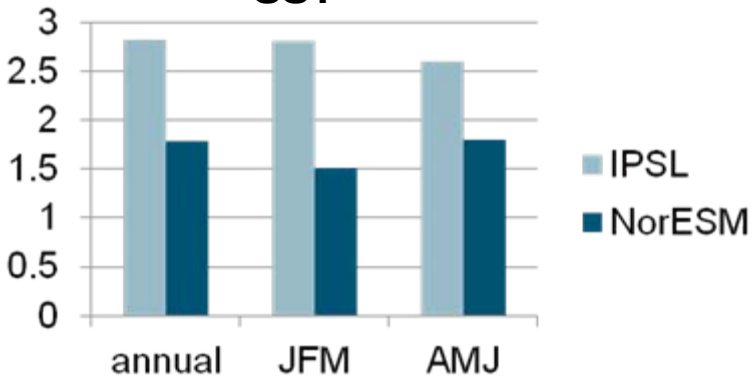
Setup climate projections

Future projections IPSL (AR4 A1B2) & NorESM (AR5 RCP 4.5)

Downscaling using delta-change approach ($P(i,j) = P_{reanalysis}(i,j) + \Delta P(i,j)$)

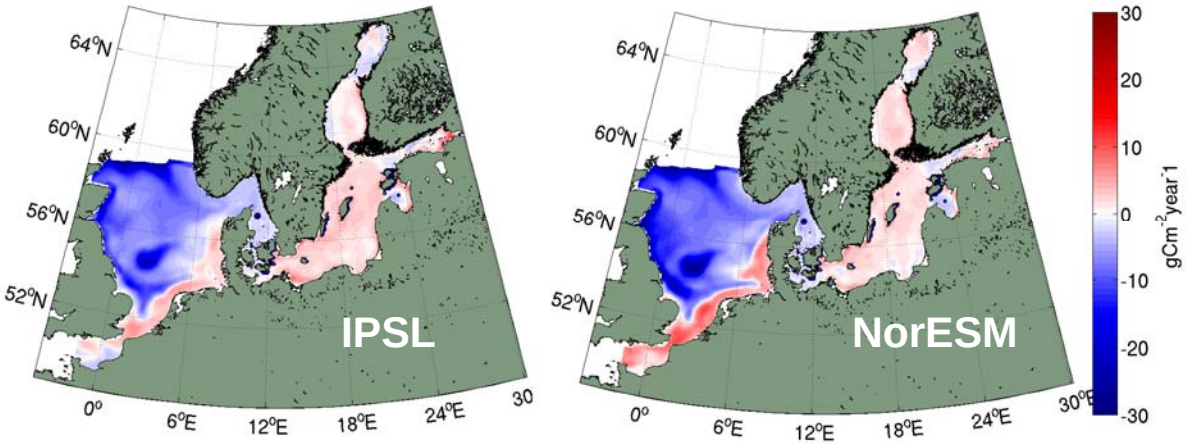
Change in environmental parameters (Forcast-hindcast)

SST



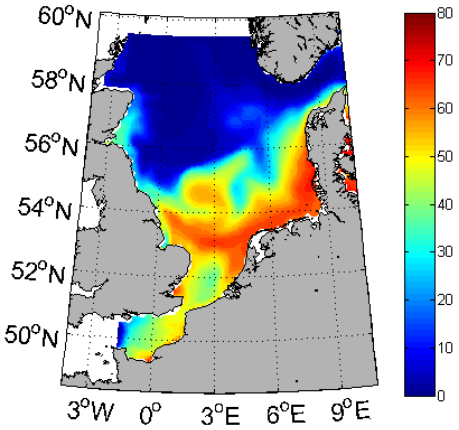
U_current vel.

Primary Production

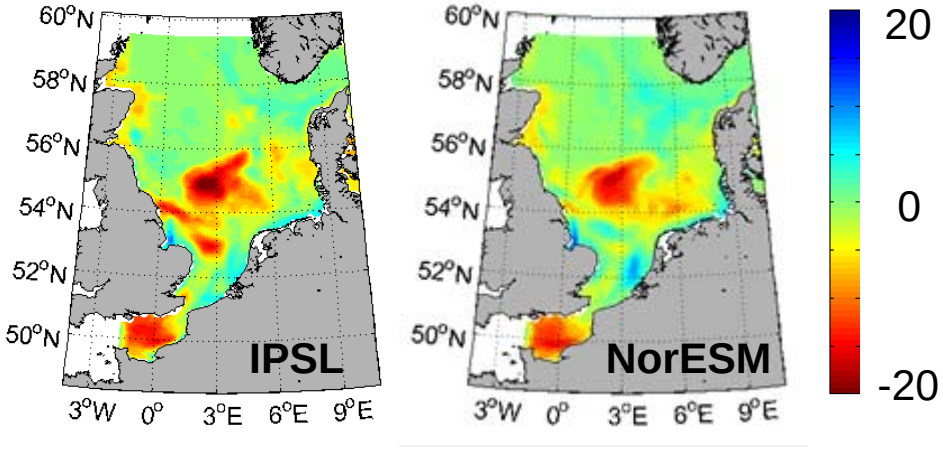


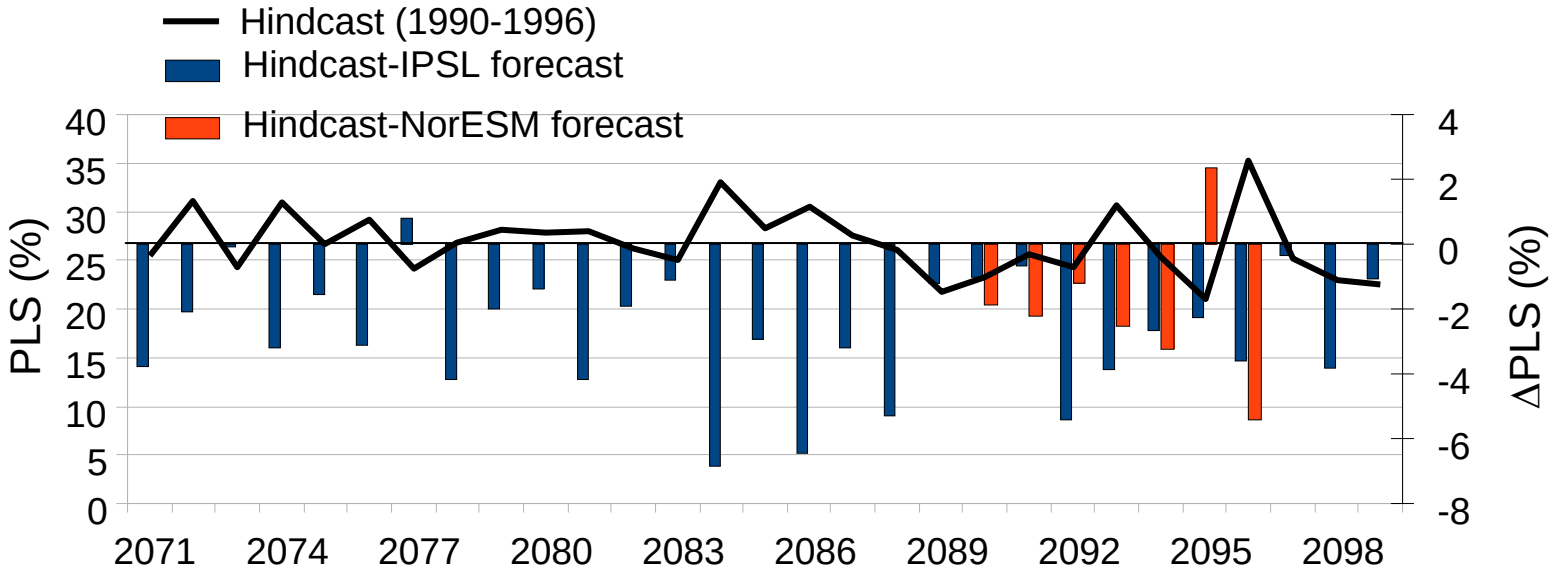
ECOSMO-IBM Projections
Potential Larval Survival (PLS)

Mean PLS (1990-1996)



Mean PLS (Forecast-Hindcast 90-96)





Summary

Long Term experiments

- large interannual variability with compareable spatial pattern
- abrupt change in PLS end of 80'ies

Scenarios

- wind: strong continously negative impact on PLS
- prey fields: strong impacts; interacting with other parameter
- air temperature: minor direct impacts

Projections

- comparable average pattern --> different underlying processes