The marine ecosystem in changing climate - on the added value of coupled climate-environmental modelling of the Baltic Sea, October 16th 2009

Biological Ensemble Modelling

to improve fisheries science & management

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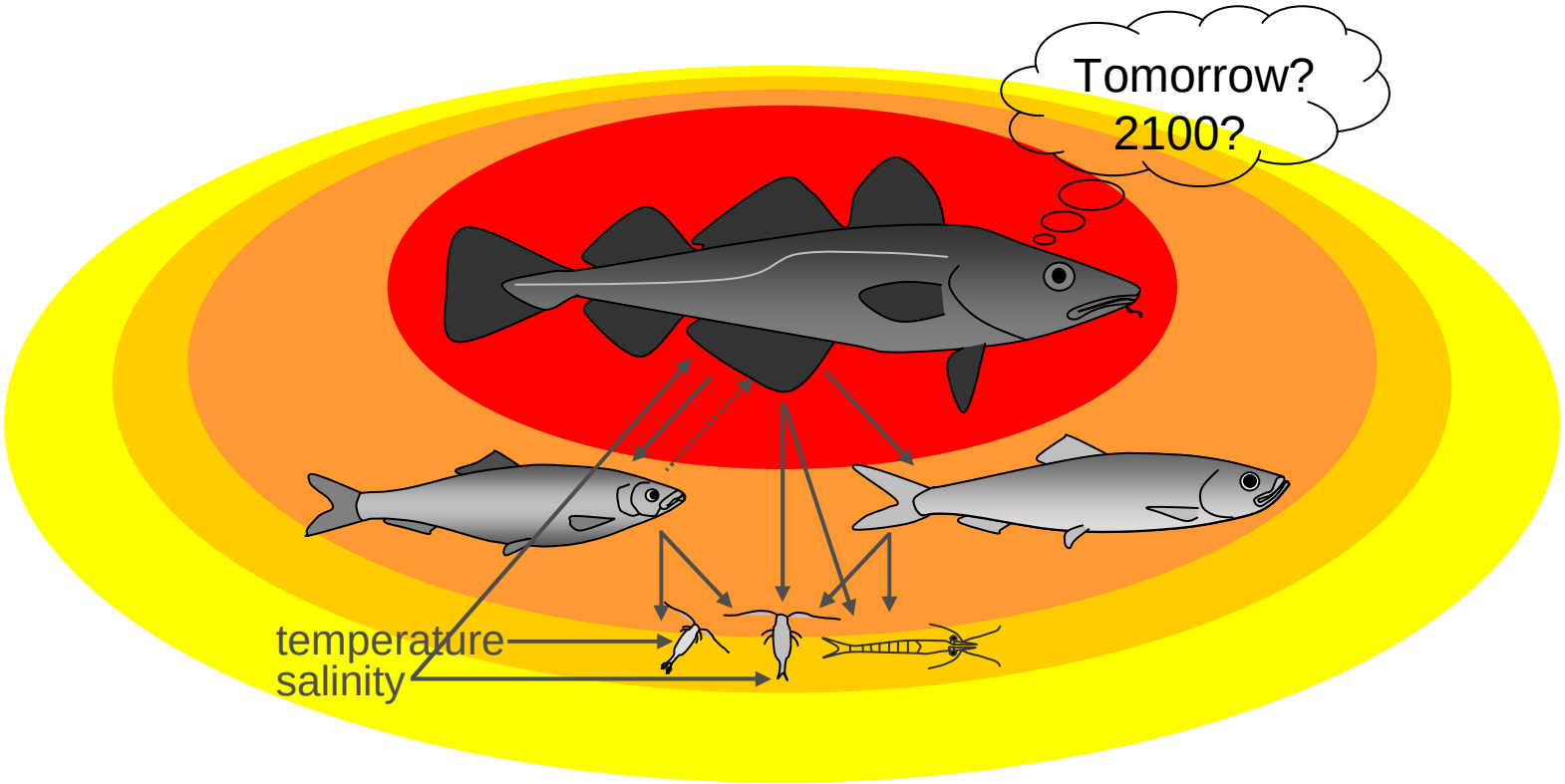
ICES/HELCOM Working Group on
Integrated Assessments of the Baltic Sea (WGIAB)

How to predict future fish populations?



Biological Ensemble Modeling Approach *(BEMA)*

- compare predictions *across models* and model types
- assess impact of model structure on predictions
- seek conclusions valid across models and scenarios

8 models of Eastern Baltic cod

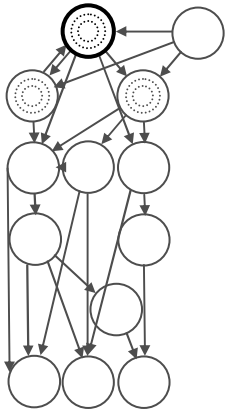
Single species

1. Wikström, A. et al.
   in prep.

2. Aro, E.; ICES (2008)

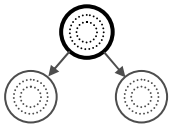
3. Müller-Karulis, B.
   in prep.

Food-web

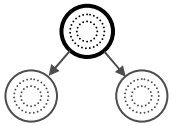


8. Tomczak et al.
   in prep.

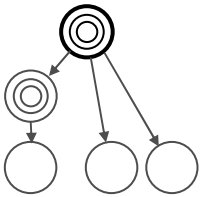
Multi-species



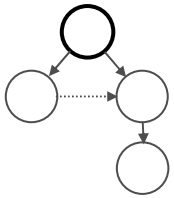
4. Heikinheimo, O. (2009)
   ICES J Mar Sci



5. Neuenfeldt, S; ICES (2004)



6. van Leeuween, A. et al. (2008)
   J Sea Research



7. Lindegren et al. (2009)
   Proc Nat Acad Sci

unstructured
age structured
size structured

Future in response to…?

Fishing

- 5 fishing mortality (constant) scenarios:
  - mean F of 1996-2005 for all species ($F_{cod} \approx 1$, $F_{sprat} \approx 0.4$, $F_{herr} \approx 0.3$)
  - cod management plan target met ($F_{cod}=0.3$)
  - cod fishing ban ($F_{cod}=0$)
  - moderately or highly intensified sprat fishing ($F_{sprat}=0.6$ or 0.8)

Climate change

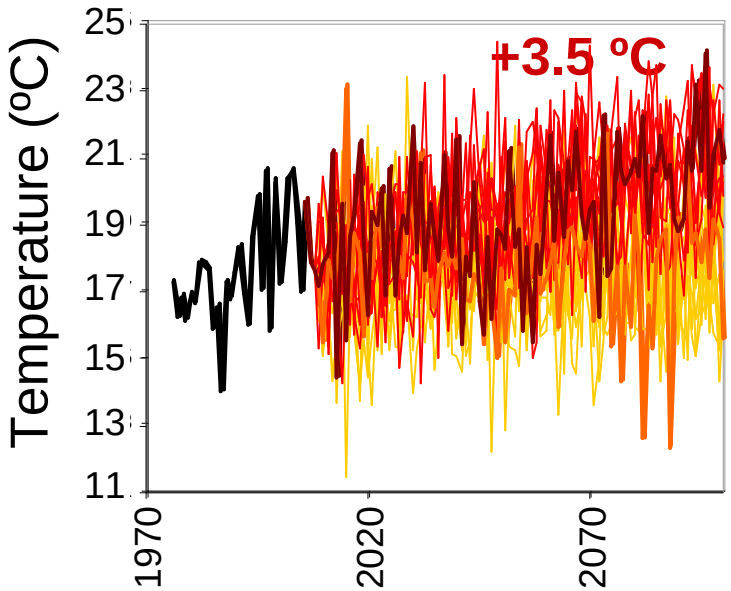
- down-scaled global IPCC scenario

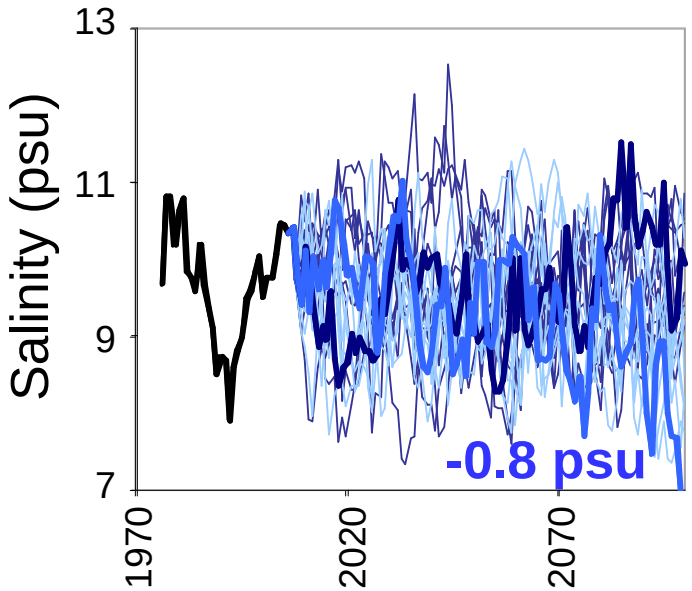
(ICES/HELCOM WGIAB 2009; historical estimates ICES SGMAB 2006)

Climate change scenario: an *example*

Hydrographic forecasts

- Global Circulation Model → Regional Atmosphere & Ocean Model → temperature & salinity forecasts 2071-2100 (Meier 2006)
- temperature & salinity 2006-2100 created based on observed mean, variance & auto-correlation 1972-2005



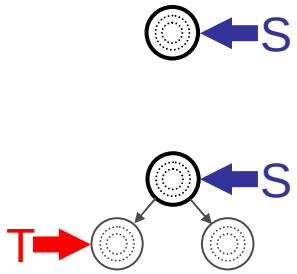


(ICES/HELCOM WGIAB 2009; historical data SMHI)

Hydrographic effects on modelled fish

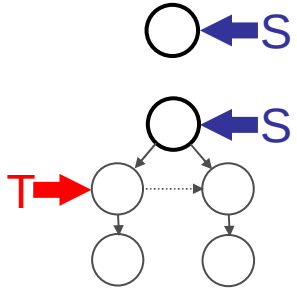
Salinity → cod recruitment
(Heikinheimo 2006, fitted to new data)

Temperature → sprat recruitment
(Baumann et al. 2002, fitted to new data)



Salinity → cod biomass

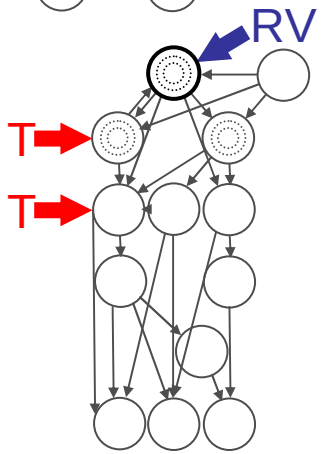
Temperature → sprat biomass



Reproductive volume → cod egg production

Temperature → sprat egg production

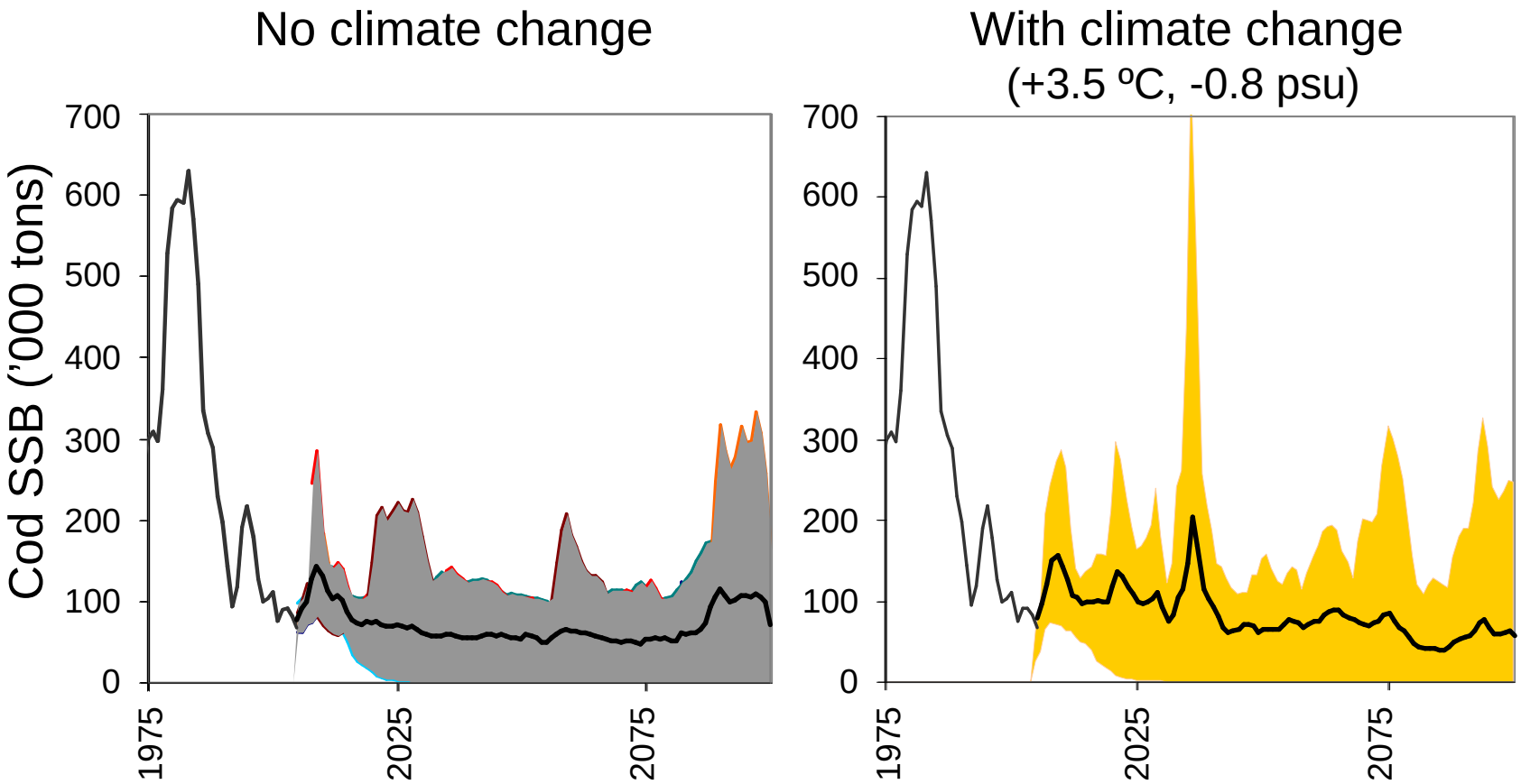
Temperature → zooplankton biomass
(some groups)



(ICES/HELCOM WGIAB 2009)

Future with intense cod fishing: *example*

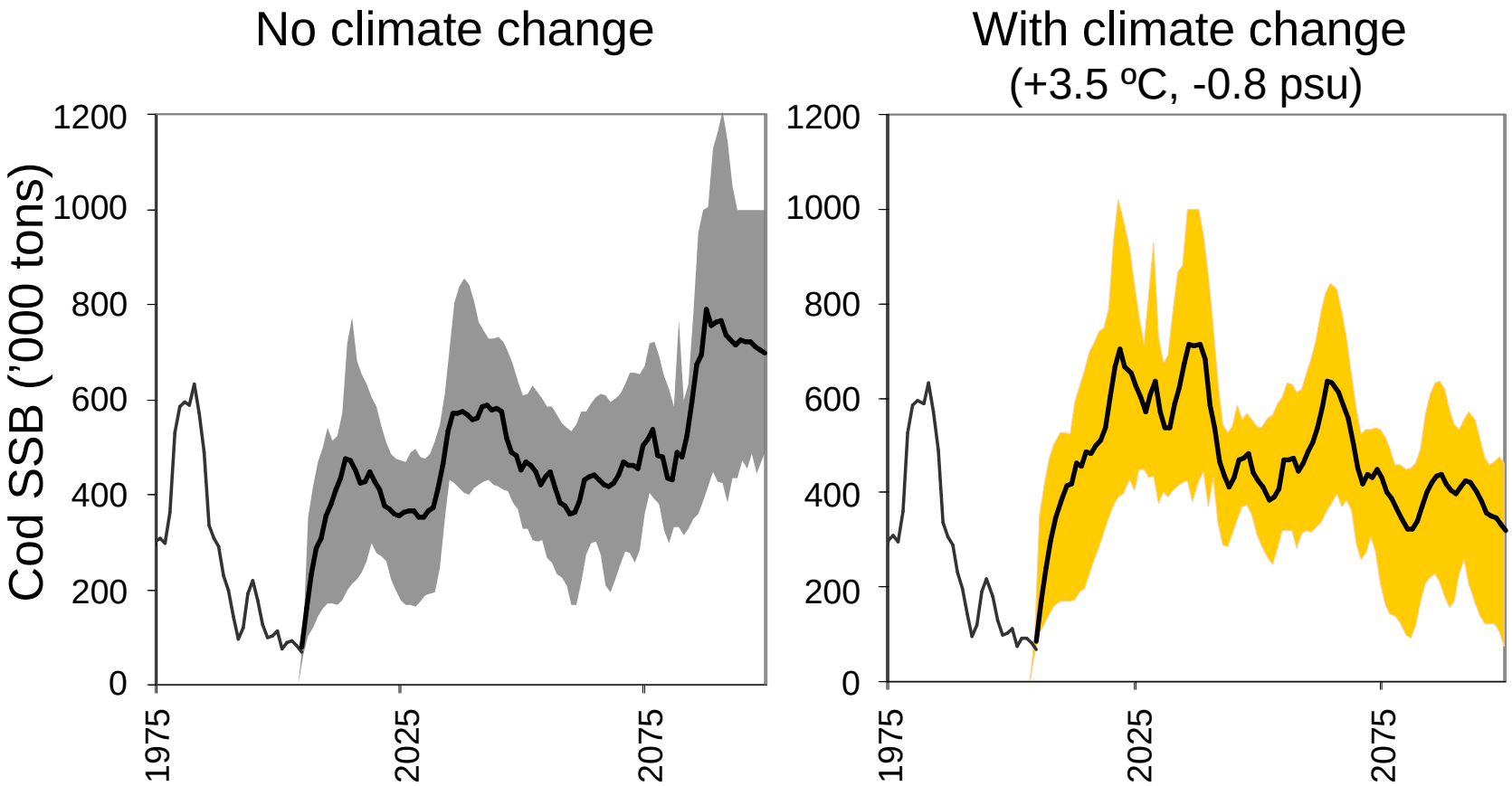
F_{cod}=1.08 (mean of 1996-2005)



(ICES/HELCOM WGIAB 2009)

Future with cod management target F: *example*

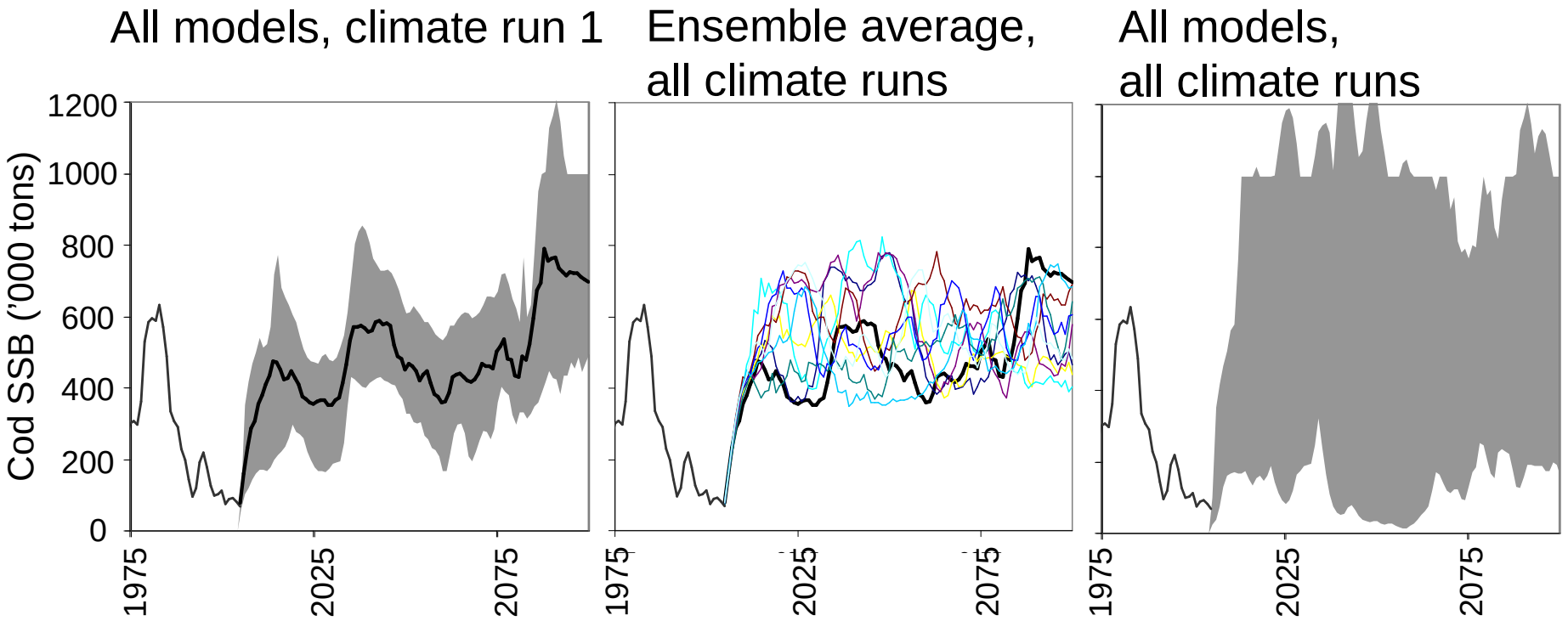
F_{cod}=0.3 (target F in EU cod management plan)



(ICES/HELCOM WGIAB 2009)

Uncertainty in scenario & model ensemble

F_{cod}=0.3 (target F) and no climate change



(ICES/HELCOM WGIAB 2009)

Conclusions across models?

Fishing	Climate	Decreases	Increases to medium levels	Increases to high levels
Intense (F=1.08)	current	7	none	none
	climate change	5,8	none	none
Mngmt plan target met (F=0.3)	current	none	none	1,2,3,4,5,6,8,9
	climate change	none	1,2,4,8	3,5,6,9
Fishing ban (F=0)	current	none	none	1,2,3,4,6,8,9
	climate change	none	1,2,3,4,6,8	9

(ICES/HELCOM WGIAB 2009)

Conclusions

- Eastern Baltic cod *example*
  - no recovery if fishing returns to mean levels of 1996-2005
  - less benefit of target F=0.3 in a future changing climate

- Biological Ensemble Modelling Approach (BEMA)
  - collate and compare possible future population developments
  - provides mean and ranges of predictions (careful use of mean!)
  - enables conclusions *across* models and scenarios

    = robust advice!

- tool for biological model development
  - identify critical uncertainties
  - identifying structural causes of model ensemble variation

    → focussed collection of field or experimental data

    → further model development

Thanks!

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Thanks to: ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea

interested?

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or look at www.ices.dk/expertgroups