



**Now you see me, now you don't:
uncertainties in projecting spatial distribution of
marine populations.**

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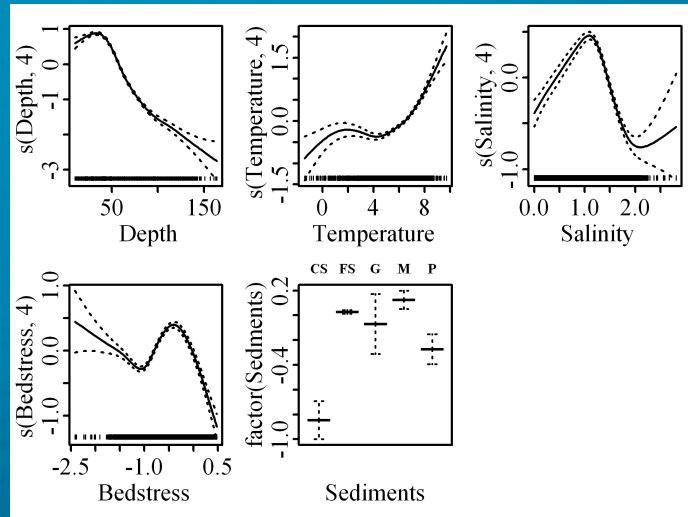
projecting spatial distributions

niche-based models

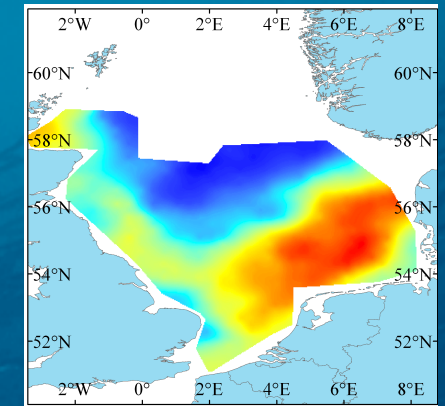
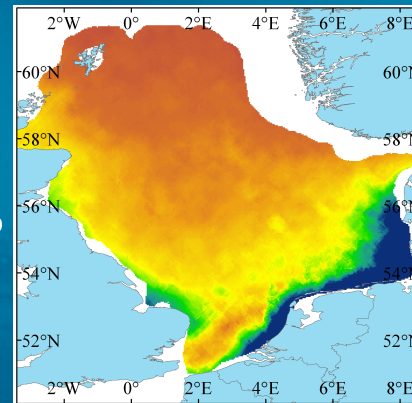
*climate
forecast/scenario*

*predicted
spatial
distribution*

biological response



+

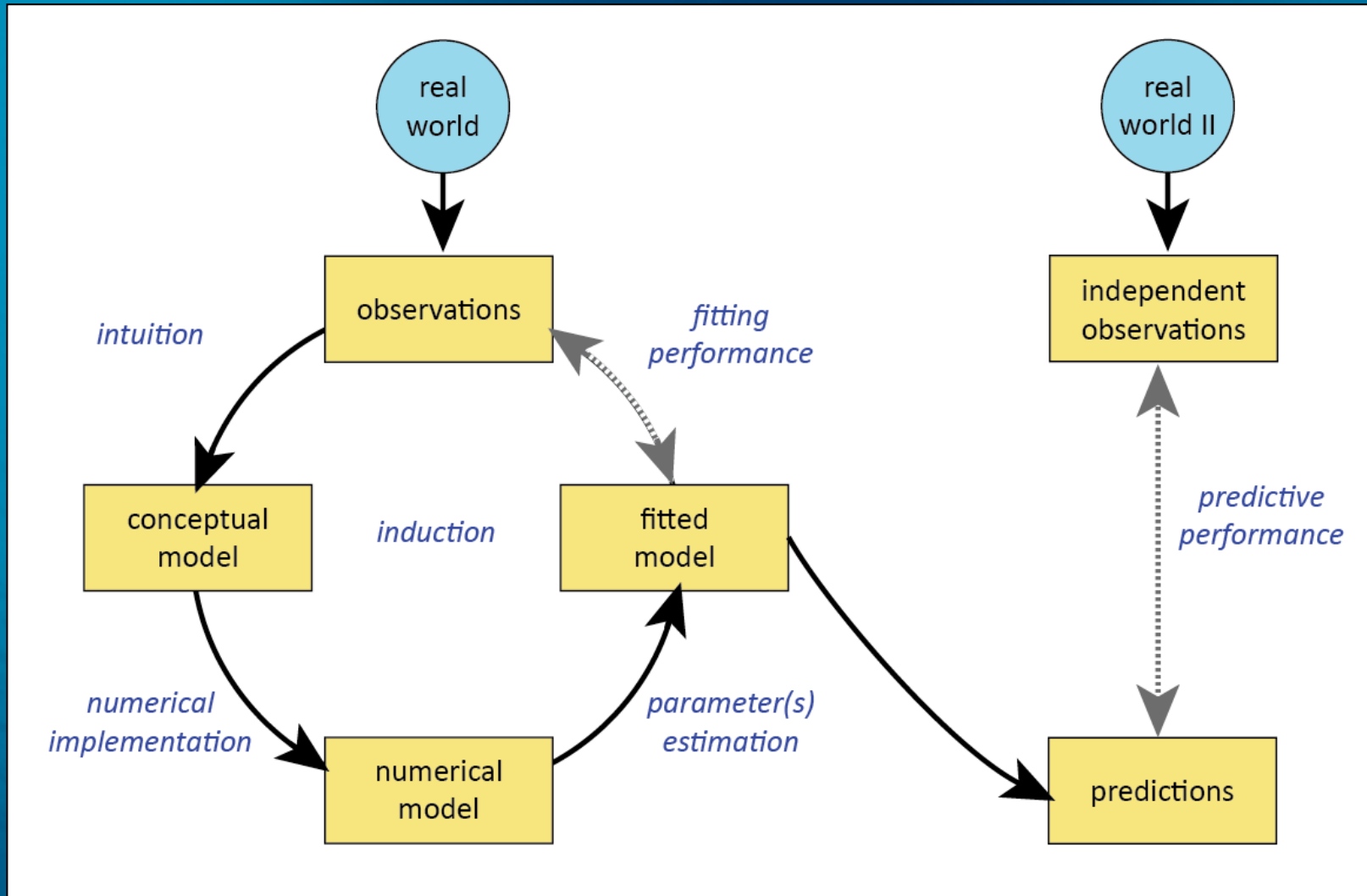


environment



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A general view of the modelling method



adapted from Anderson, 2010



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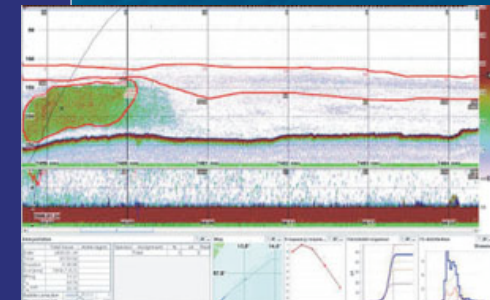
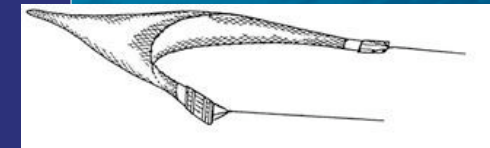
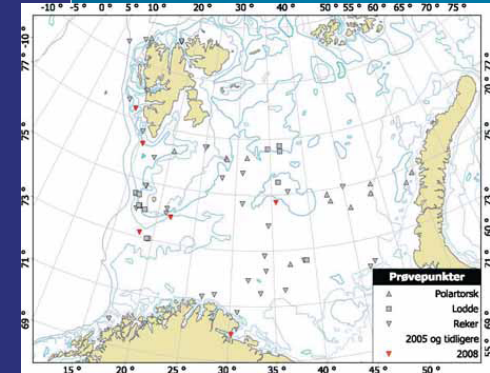
uncertainties in observations

sampling design:

*sampling intensity, spatial/temporal scales,
aggregated distributions*

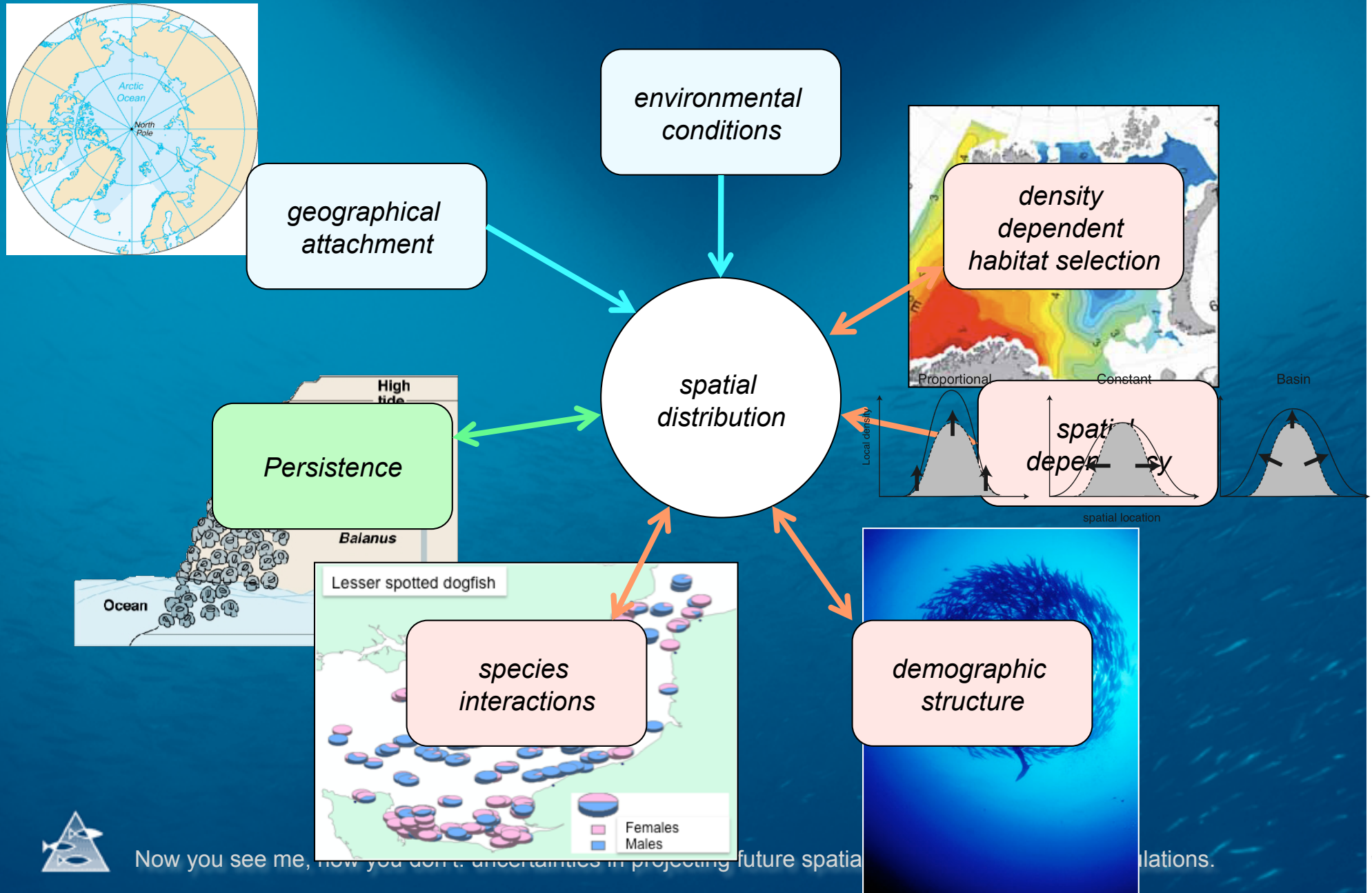
sampling gear (trawl) or observation (acoustics):

*accessibility to observation, sensitivity, bias and
precision*



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uncertainties in conceptual models



uncertainty in numerical formulation

functional relationships

linear, polynomial, piecewise, etc...

model complexity

number of parameters, non-linearity

interactions

additive, multiplicative, other

statistical distributions

Normal, Poisson, Log-Normal, Gamma, Binomial,...



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statistical distribution of parameters

confidence intervals, statistical significance

correlated parameters

are parameters independent, and how is this handled by the modeling method?

overparametrisation and overfitting

number of parameters vs. number of independent observations

autocorrelated observations

spatial/temporal autocorrelation reduces the true number of independent observations

metric for model fitting performance

variance, deviance, likelihood, AIC, AUC, GCV,...



uncertainty in model evaluation

metric for model predictive performance

variance, deviance, likelihood, AIC, AUC,...

true independence of the validation data

are the validation data correlated with fitting data?



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Spatial scale

is spatial scale considered?

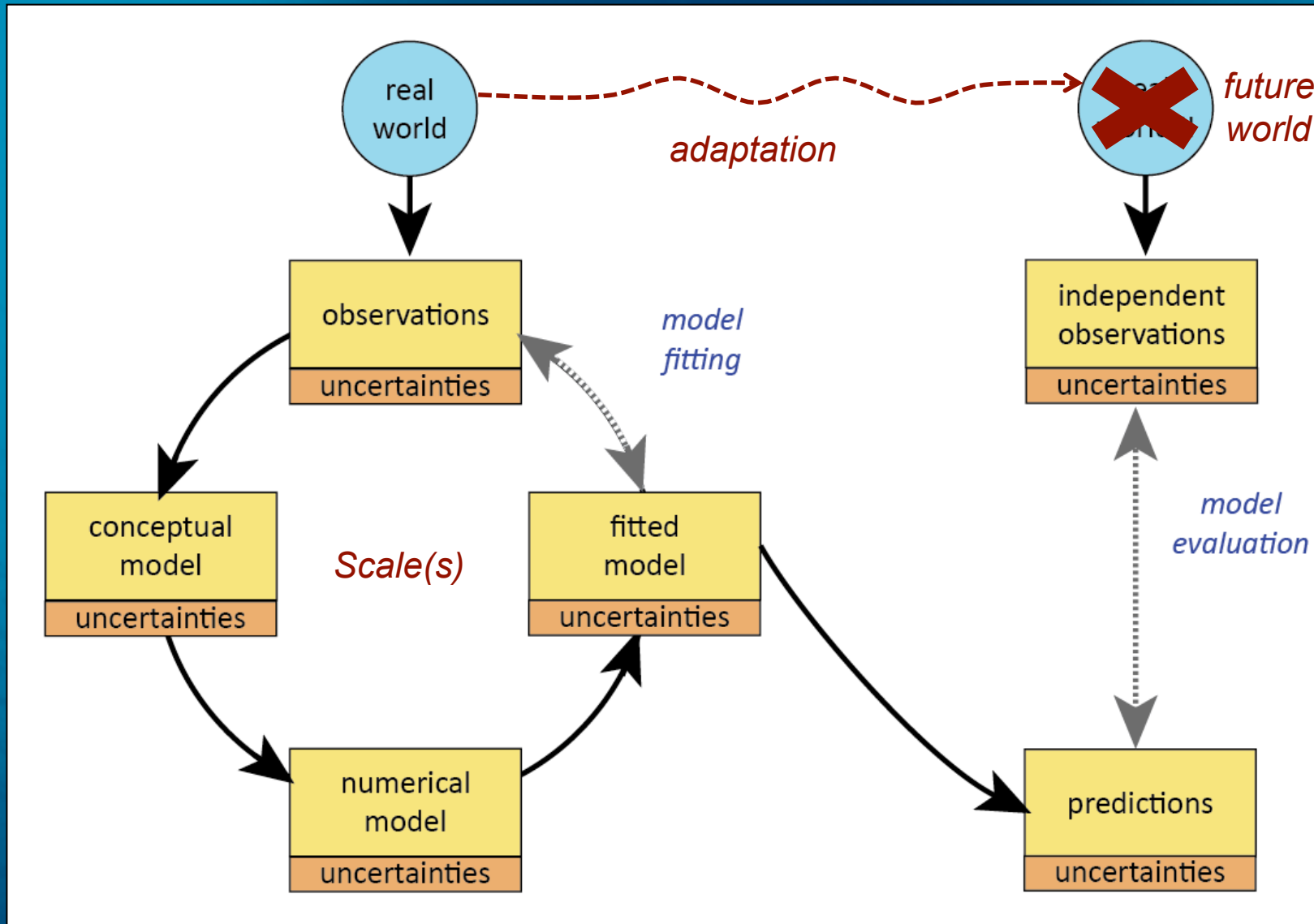
are the scales of observation and modelling consistent?

adaptability of living systems

complex adaptive systems, these may modify their behaviour in the future, surprise is to be expected



Evaluating uncertainties



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How are these uncertainties currently handled?

survey of the published literature 2005-2010

[<< Back to previous](#)

Results TS=((spatial or geograph* or distribution* or habitat) and (fish* or benth*) and (sea or ocean or coast* or marin*) and model*)
Refined by: Subject Areas=(MARINE & FRESHWATER BIOLOGY OR OCEANOGRAPHY OR FISHERIES)
Timespan=2005-2010. Databases=SCI-EXPANDED, SSCI, A&HCI.

Results: **1,137**

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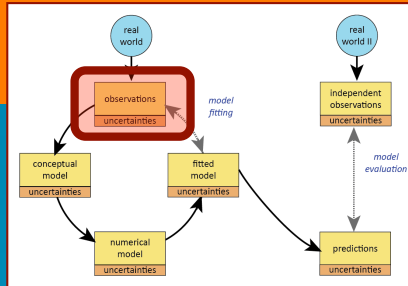
Sort by: Latest Date

1137 articles -> 75 retained, which are developing models which are (or can be) used in a predictive fashion.



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Observations



*Observation
uncertainty*



7%

*Observation
model*

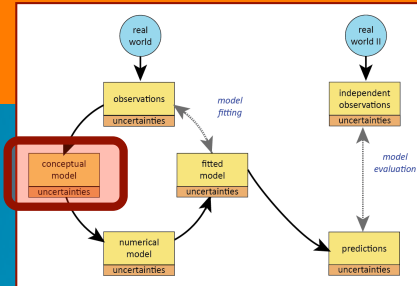


1%



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Conceptual model



19% *Geographical attachment*



95% *Environment*



11% *DDHS*



27% *Spatial dependency*



9% *Demographic structure*



7% *Species interactions*



7% *Persistence*



7% *Other hypotheses*

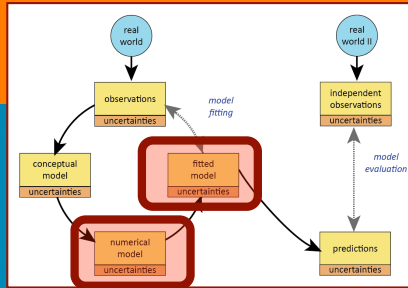


3% *conceptual model uncertainty*



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numerical model and parameter uncertainties



*numerical model
uncertainty*

*Parameters
uncertainty*



24%

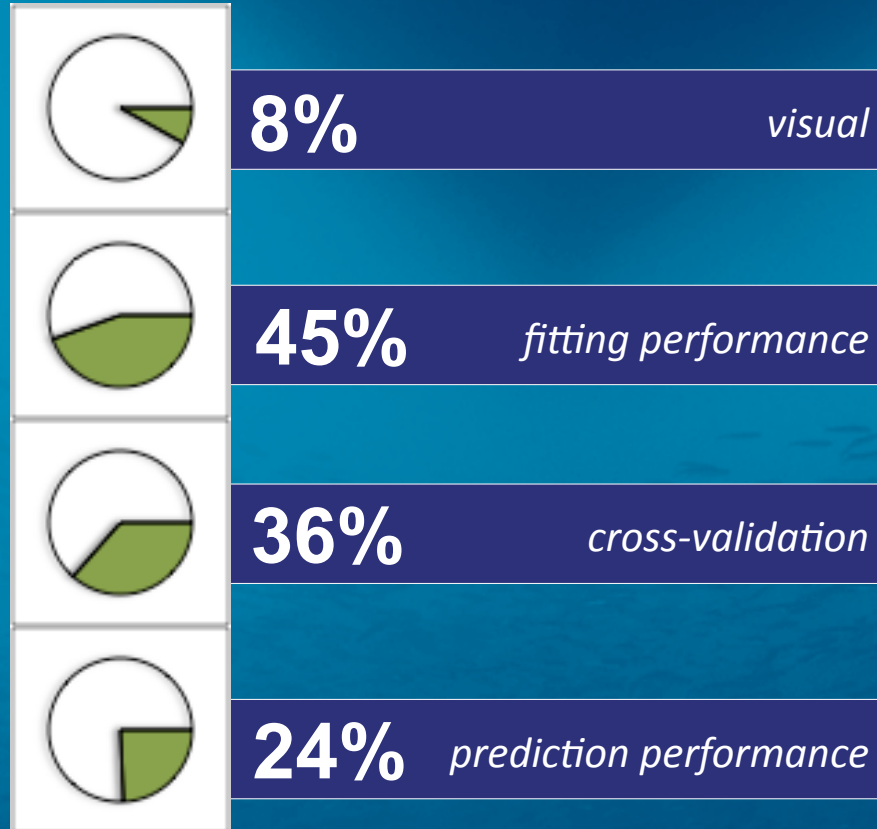
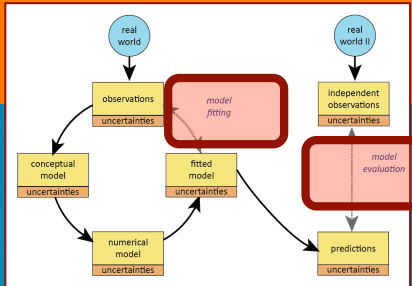


69%



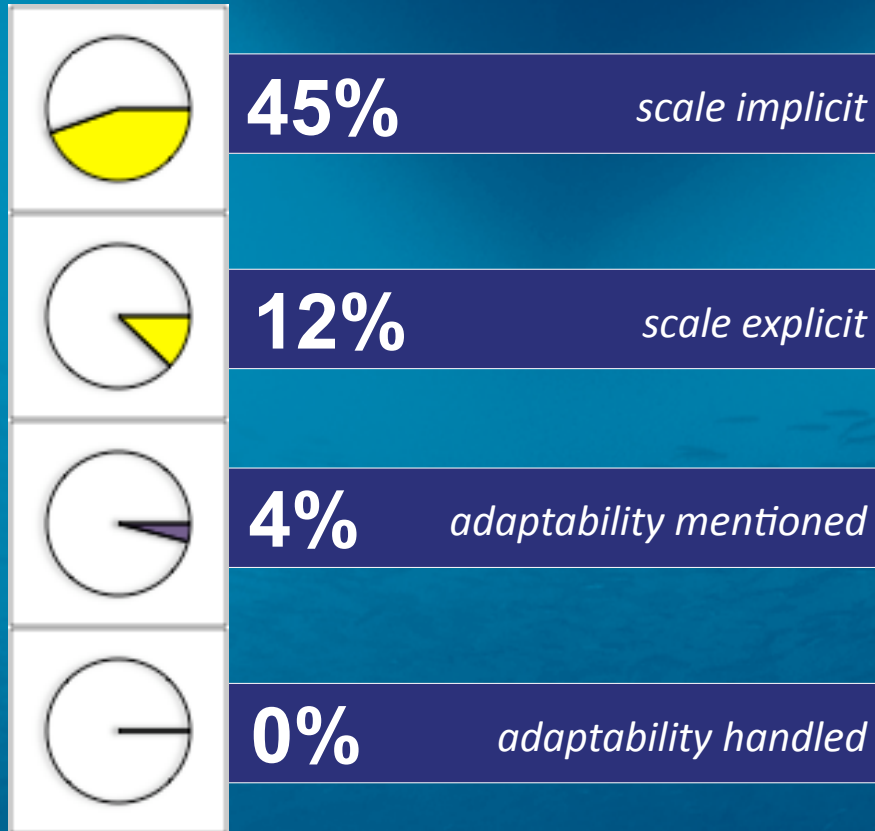
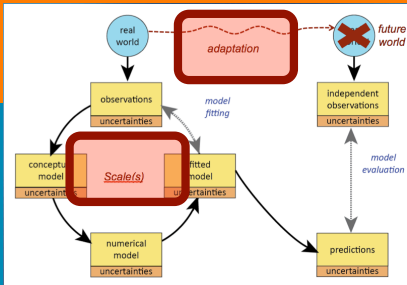
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model evaluation



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spatial scale and adaptability



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Review summary

- Uncertainty is seen primarily as parameter uncertainty
- Observation uncertainty is poorly investigated and not modelled
- Conceptual model uncertainty is generally ignored and environment models heavily dominate (+ spatial autocorrelation a little)
- Model validation is only performed on independent datasets in 1/4th of the studies analysed
- Adaptability of marine systems remains largely ignored

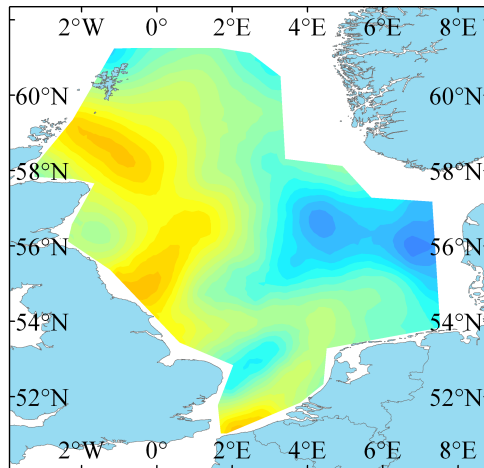


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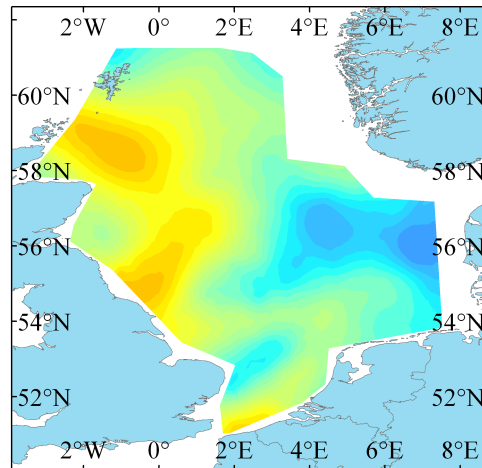
An example of uncertainty in the conceptual model

North Sea whiting: three different candidate models with equivalent predictive power

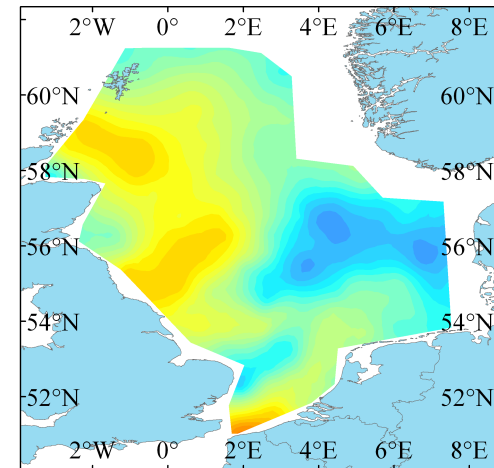
Model 1



Model 2



Model 3



- Geographical Attachment
- Environment
- Population size
- Population Demography
- Population Memory

- Geographical Attachment
-
- Population size
- Population Demography
- Population Memory

- Environment
- Population size
- Population Demography
- Population Memory

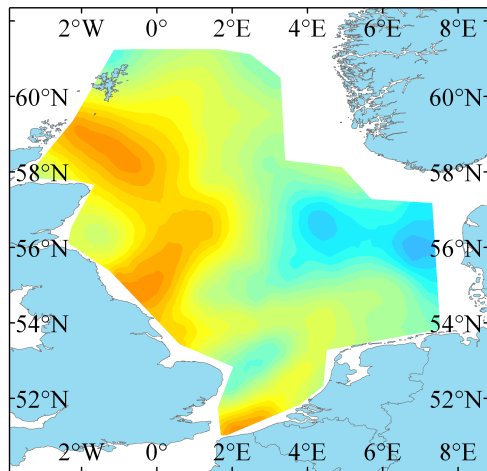


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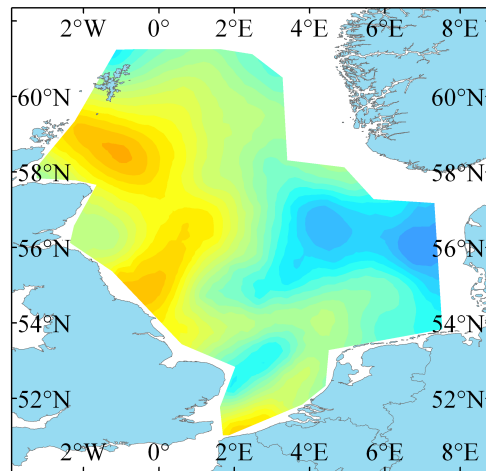
An example of uncertainty in the conceptual model

Prediction under a scenario with 2°C temperature increase

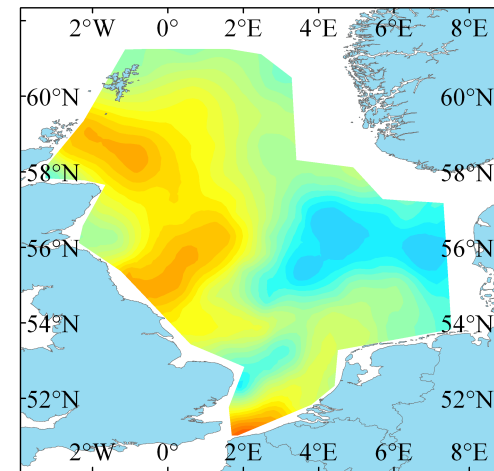
Model 1



Model 2



Model 3



Models 1 and 3 (with environment) forecast an increase of abundances whereas model 2 without environment does not forecast any change

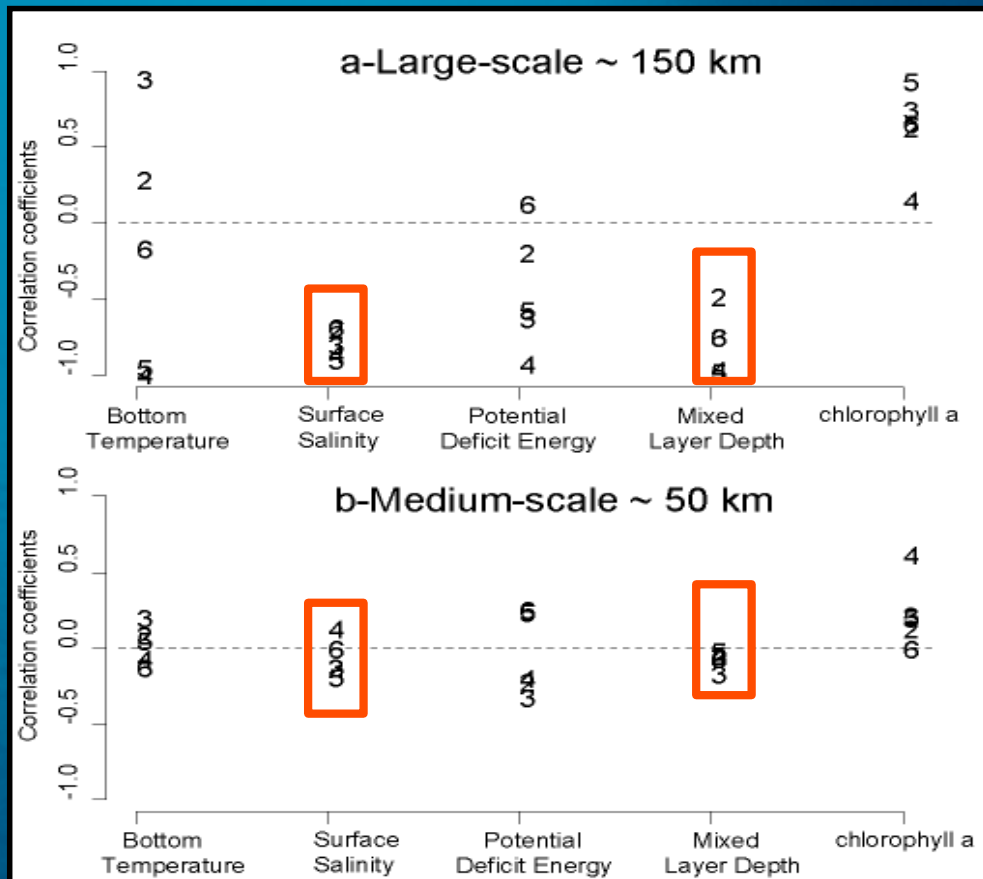
Three models with equivalent present-day predictive power, forecast different distribution with future conditions
= uncertainty in predictions due to conceptual model uncertainty



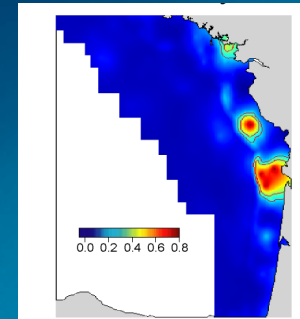
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An example of explicit account of scale

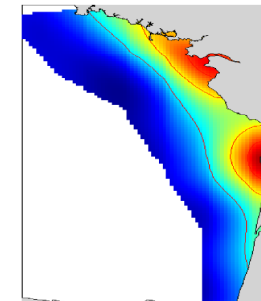
Correlation between the presence of auks (*Uria aalga*) and several hydrographic parameters, at 2 scales



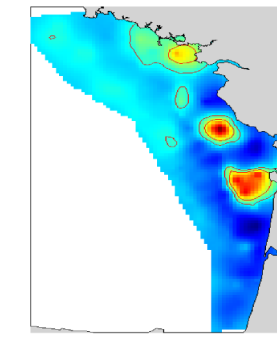
Strong correlation at large scale
and weak correlation at finer scale



observations



environmental
model
at large scale



environmental
model
at medium scale



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Bellier et al. in press

Conclusion

Reliable projections of future spatial distribution of marine populations requires that uncertainty is considered in its entirety, from observations to concepts, numerical models and the potential for adaptations of living marine systems.

The lack of clear recognition of various sources of uncertainty, as is the case today, limits our ability to produce reliable, believable, and ultimately useful predictions.



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Thank you

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A post doctoral position is open to work on spatial distribution models in Tromsø for three years, starting in September 2010.
If you are interested, please contact me: benjamin.planque@imr.no



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