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

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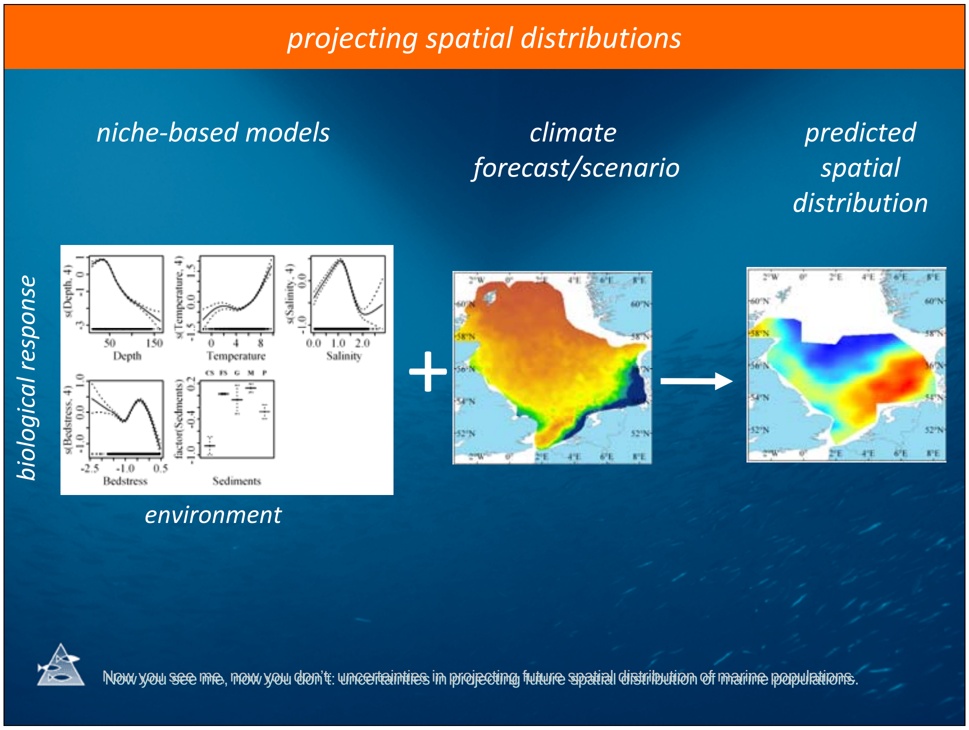
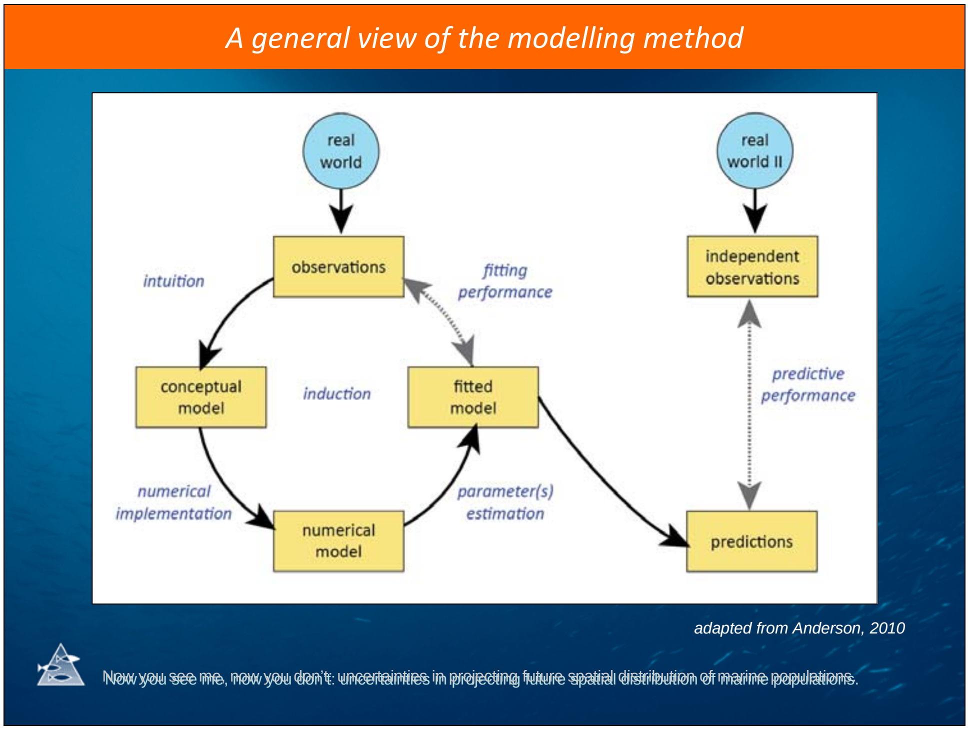


Start straight with an example: climate envelope models. Niche-based example: the niche is defined. The current realisation of the niche is the current spatial distribution. If the spatial distribution of temperature changes, then the spatial distribution of the population is also expected to change, following the geographical displacement of the niche.

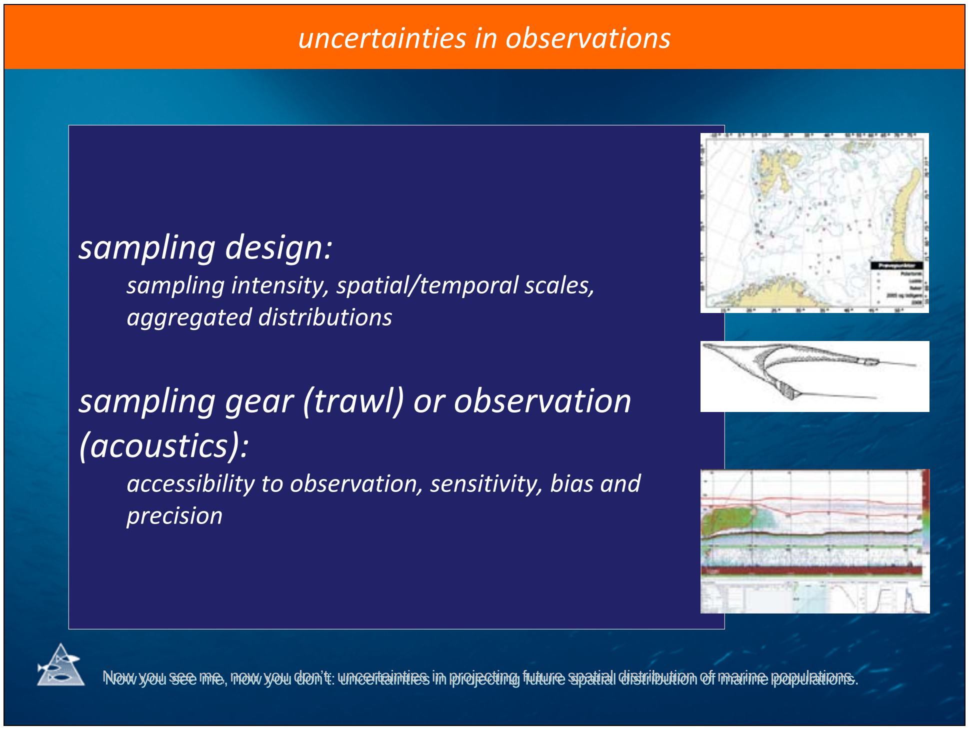
This is a simple, one can say simplistic, vision of how to build spatial distribution models. The process is in fact generally more complicated, even if many steps are often implicitly considered, i.e. explicitly ignored.

NOTE: The best would be to use the same example here as later to show variations in model output as a function of model uncertainty.

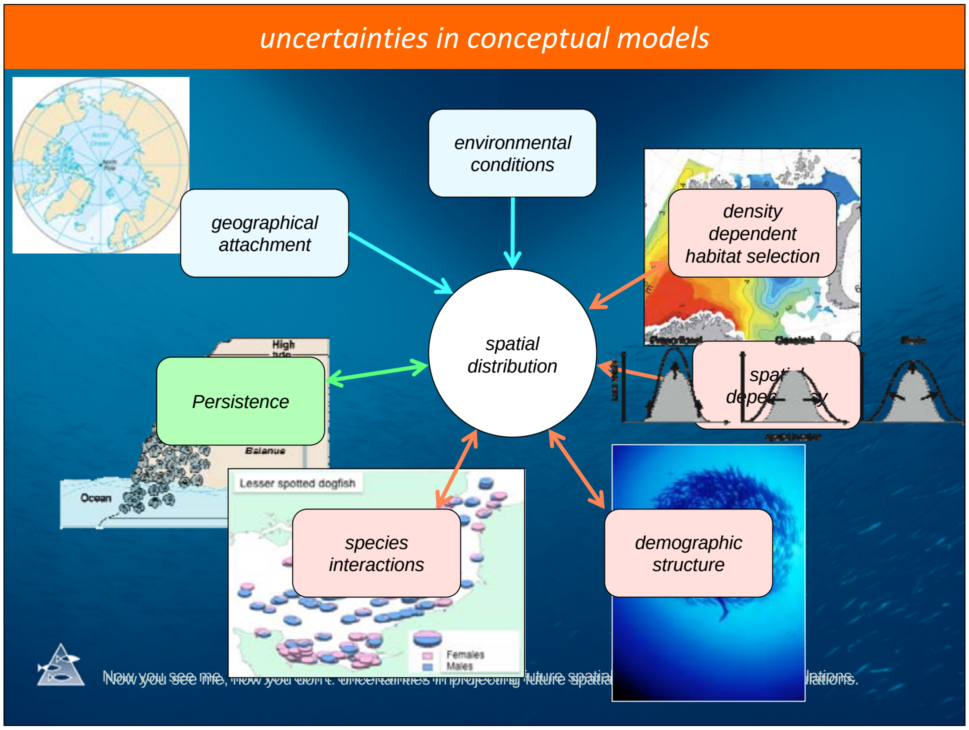


Here, I present a general view of the modelling method which explicitely state the different steps in the modeling process, from observations to prediction.

The modelling method, or how do we move from the real word towards predictions of what the world could look like in the future, or under scenarios. After explaining the different steps, we asked ourselves what uncertainties are associated with these different steps. This is developed in the coming slides.

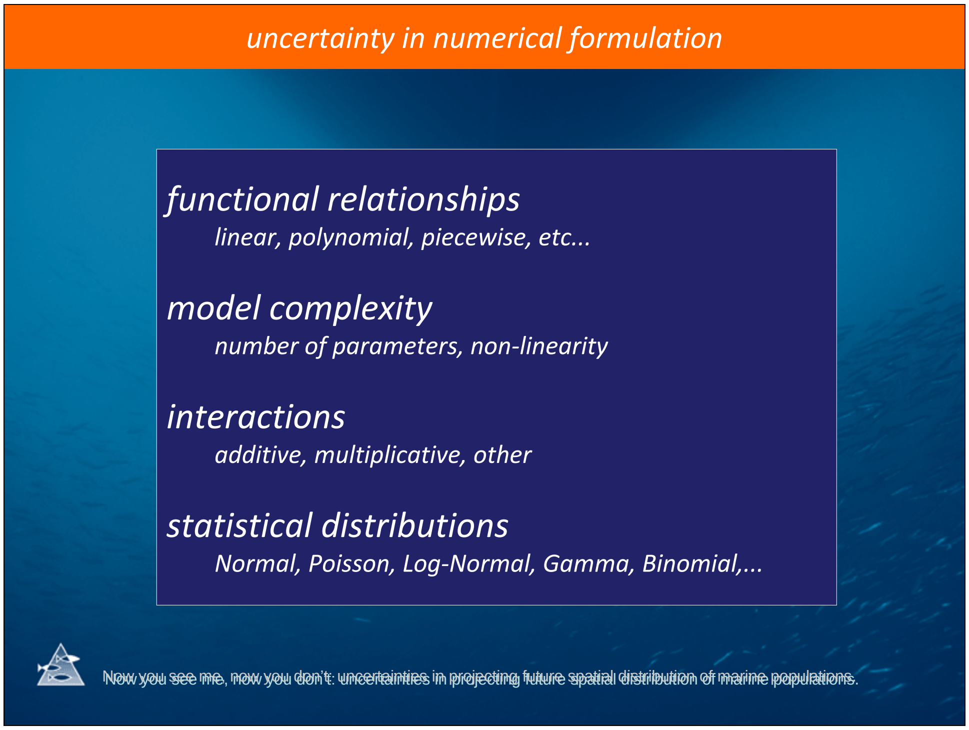


#1 Uncertainty in observations: we can only seethe real world through the lenses of our observation methods. This results in observation uncertainty which is a direct function of the sampling design and observation tools.



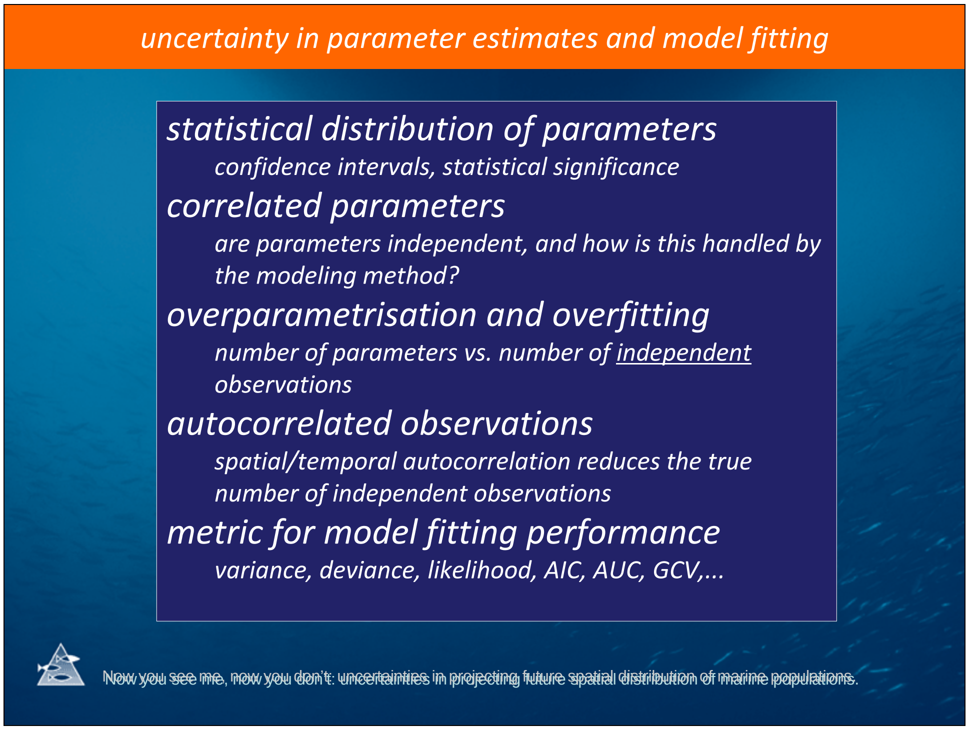
#2 Uncertainty in conceptual models. These are build from intuition and historical developments within the research community.

Conceptual models come in many shapes. We first include environmental conditions, which include e.g. temperature as before as well as other varying environmental factors or stable ones (bottom rugosity, tidal friction, etc.). Then we add 5 others (spatial dependency, DDHS, demographic structure, species interactions, memory, And finally, the geographical attachment, which constitute the null model under very poor knowledge (animals are there because they are there!). With this, we can start thinking that environmental control is not on its own and that it needs to be rather strong to override all the other controls. How much each of these conceptual models is attached to the truth is often uncertain and several model (which can include several of these hypotheses) may compete often without excluding one another.



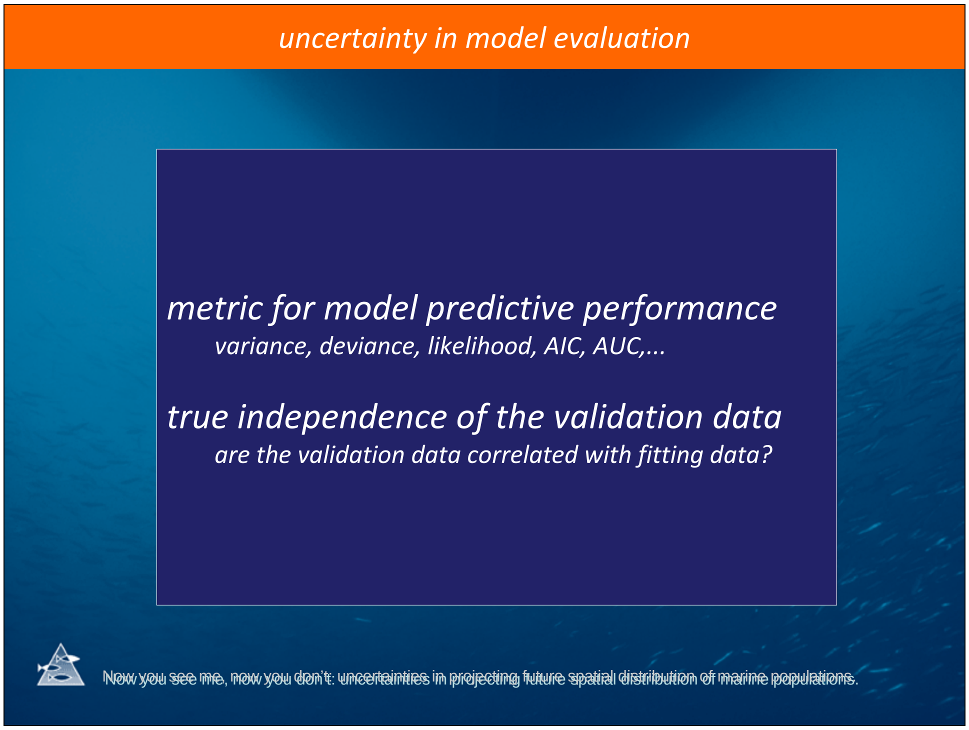
#3 uncertainty in numerical formulation of models.

Once we have selected a number of candidate conceptual models, these must be specified in numerical form. Again the choice of the numerical form can be wide and there are uncertainties into which form may be best suited to express the concepts.



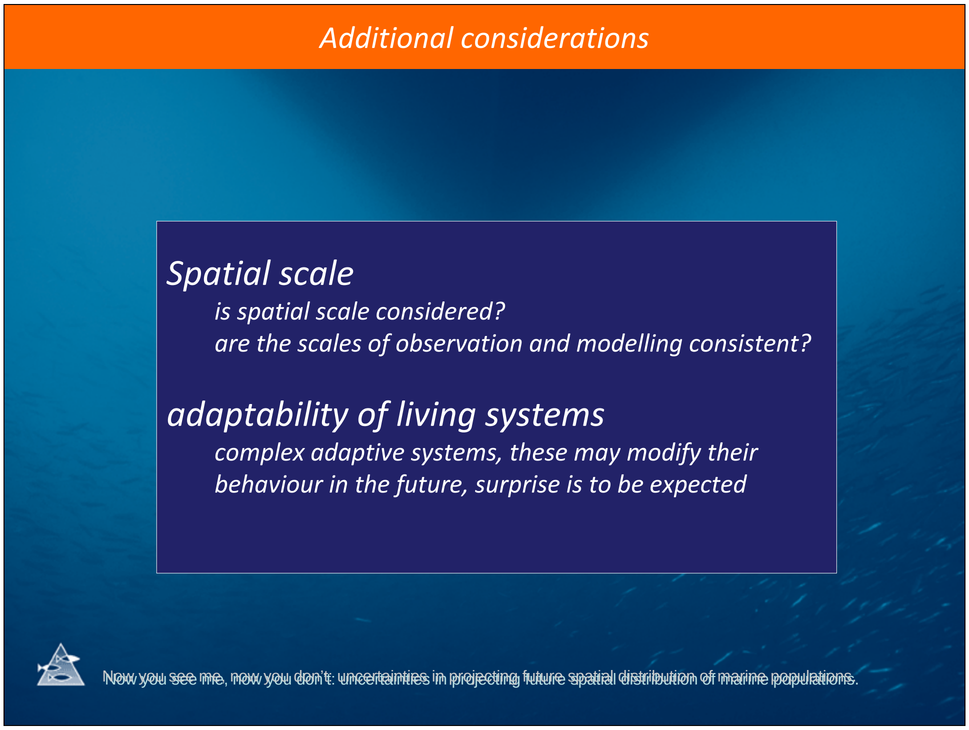
#4 uncertainty in parameters estimates and model fitting

After the numerical formulation(s) have been set, the parameters of the models must be estimated and this is generally achieved through model fitting. Again, there is uncertainty in the values of the parameters estimated and this can be sensitive to the data properties, links between parameters, model complexity and the metrics chosen to evaluate model fitting perfomances.



#5 uncertainty in model evaluation

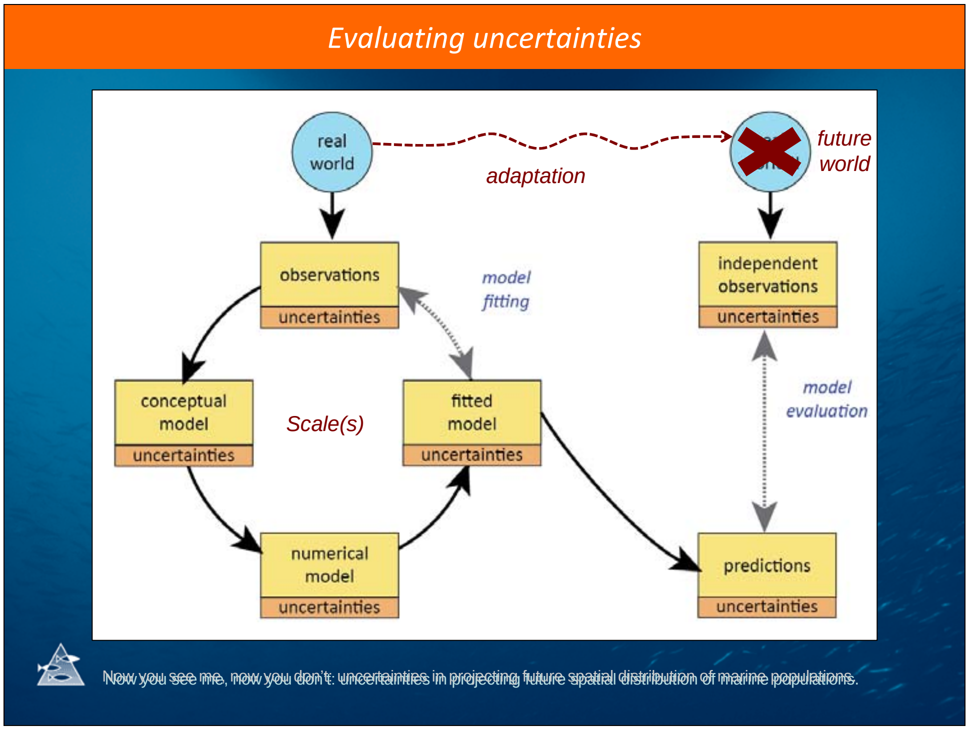
Once a range of concepts, numerical formulation and parameters are developed, the models should be evaluated for their predictive performances. This should be done on truly independent data, using appropriate metrics.



#6 some final considerations

The issue of scale is critical, since processes that govern the distribution at individual level, groups of individuals, population or species level may differ.

In addition, one must not forget that living systems are highly complex and adaptive and that their response to various kinds of controls may vary in the future as a result of such adaptive capabilities.



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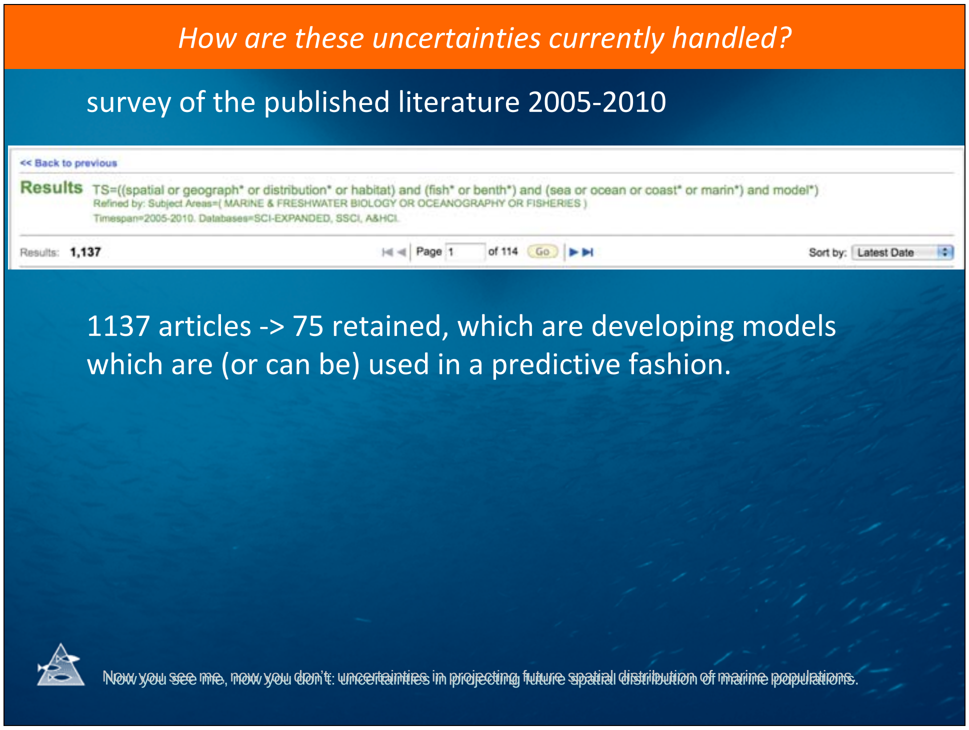
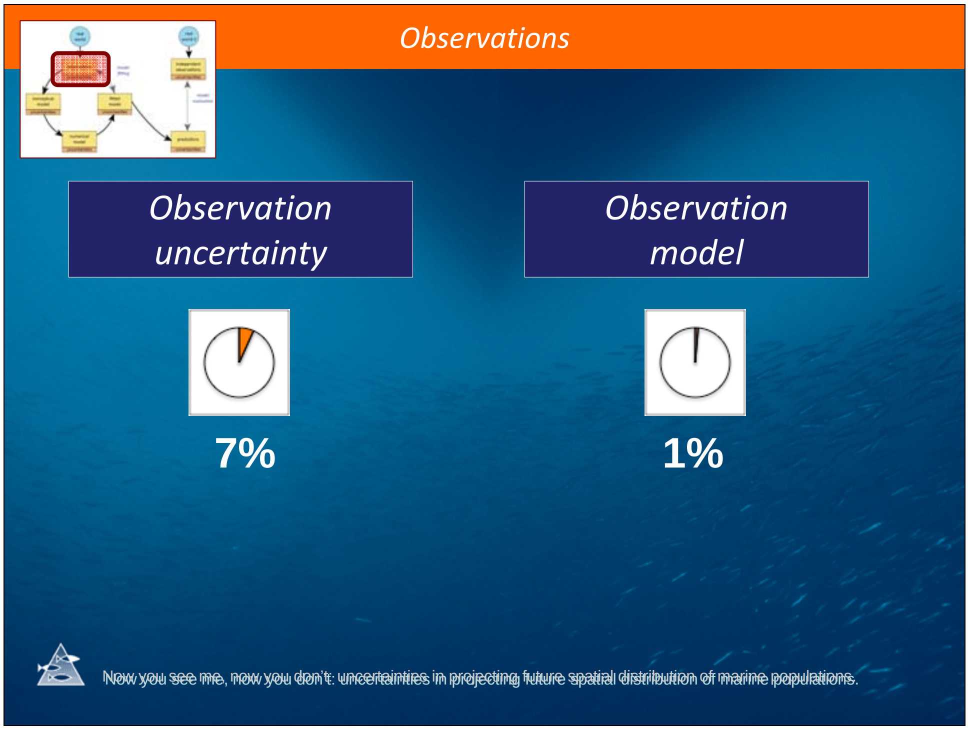


We investigated through a review of published papers over the last 5 years. Extracted from ISI (show figure). We only retained articles that were developing models which were or could be used in a predictive fashion.

1. the hypotheses



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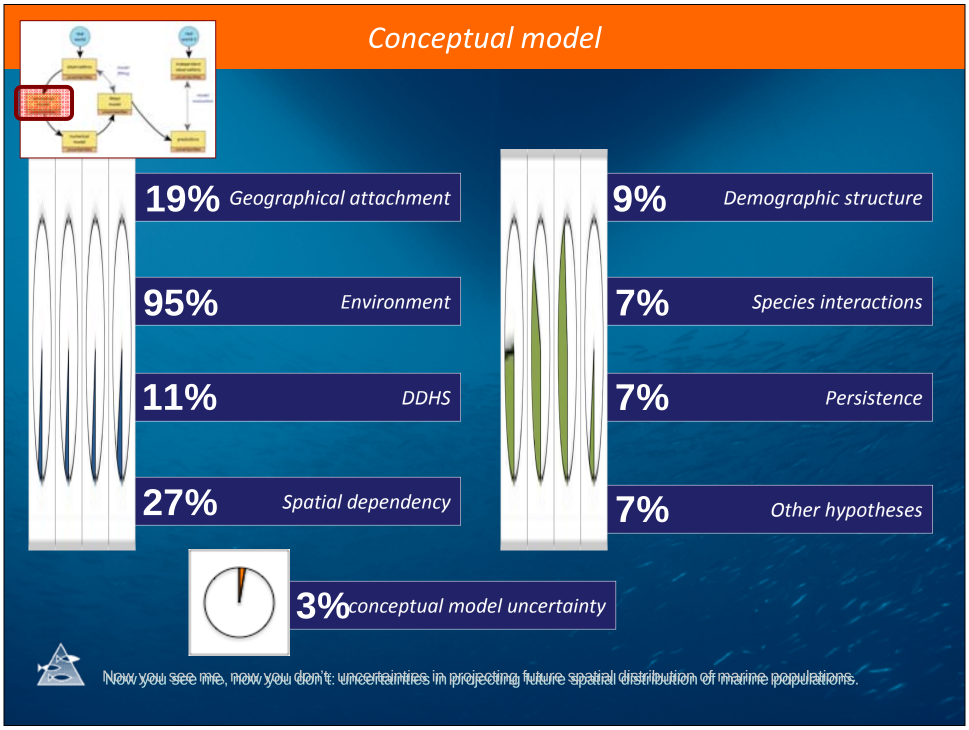
2. Estimating the uncertainties



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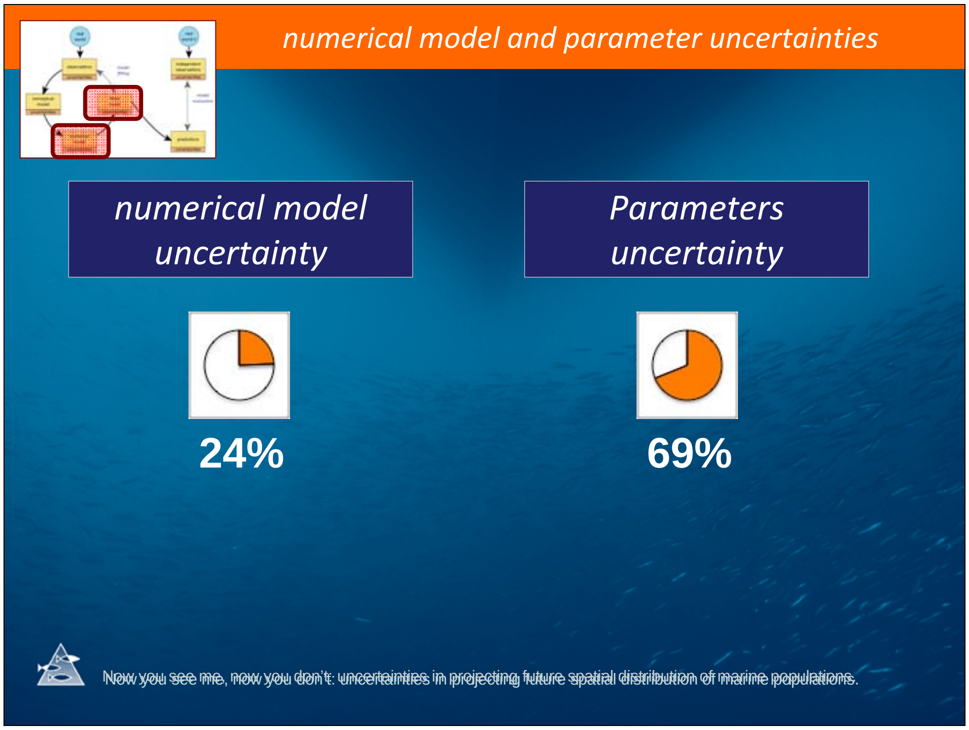
3. Model evaluation, observation model



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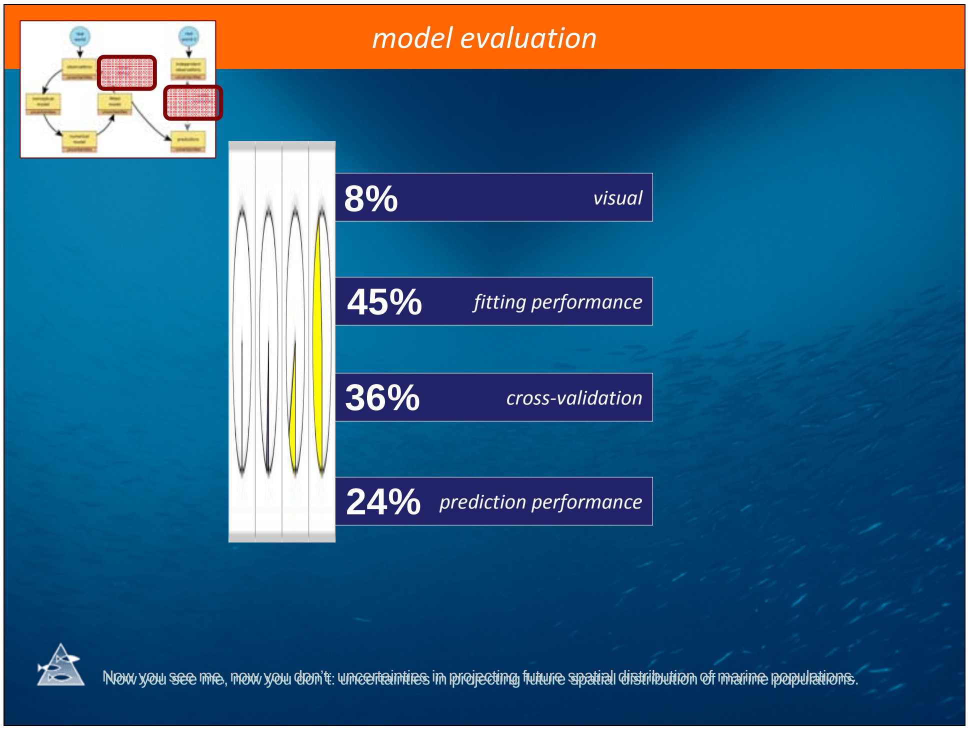
4. Scale and adaptability



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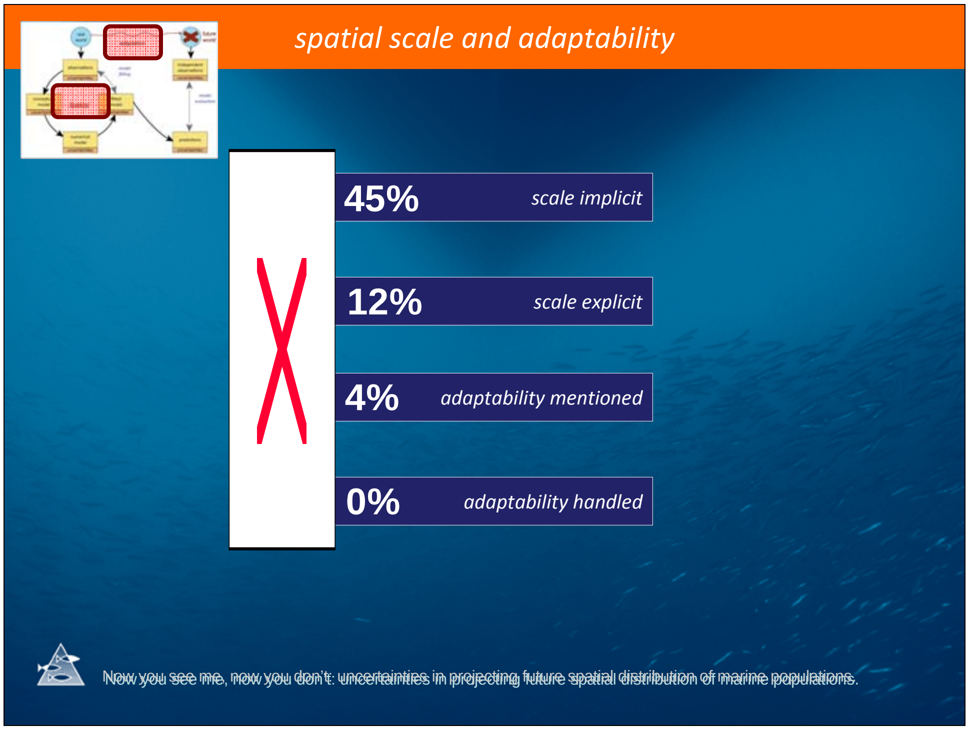

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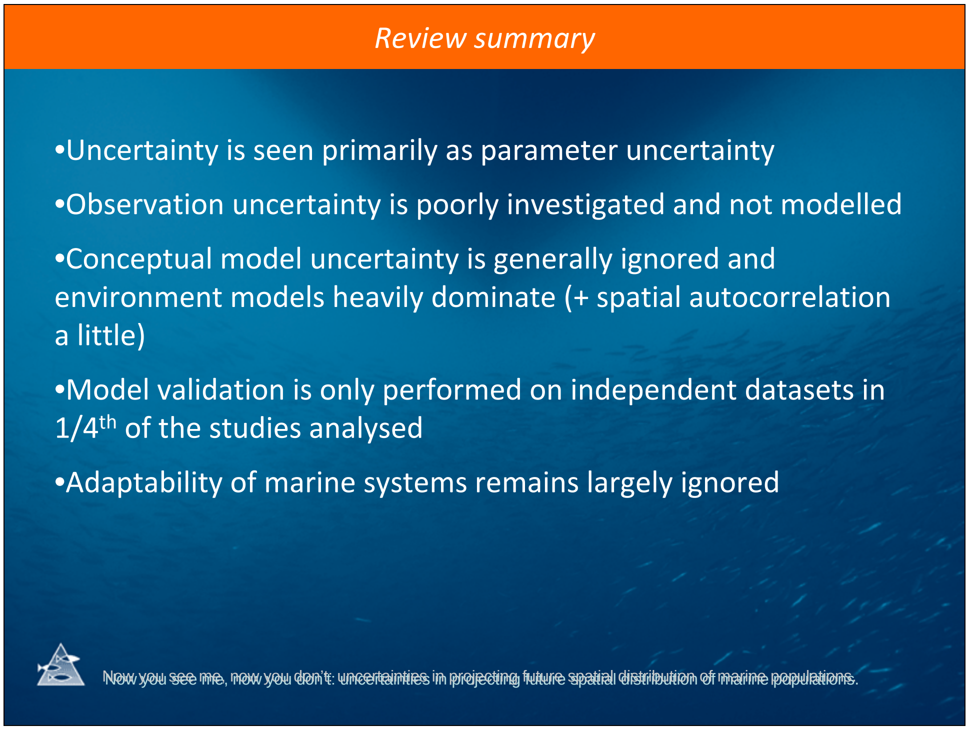


Conclusions:

1. Uncertainty define our ability (or lack of) to provide an advice on the possible fate of marine populations under climate change. Ignoring uncertainty is ignoring the value of the result presented. It is therefore key that the is quantitatively determined in any attempts to project future species distributions (this point may be moved to the introduction).

2. Because what controls spatial distribution or marine populations is more than just temperature, model development is complex and the uncertainties are present in many areas (climate models, parameter estimates within one model, model uncertainty within a single hypothesis, and uncertainty in the hypotheses themselves)

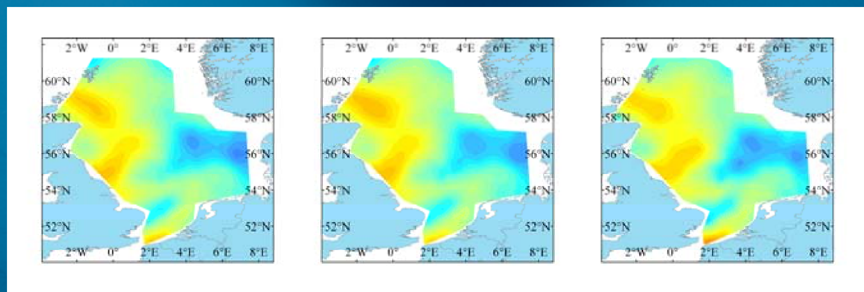
3. The consequences on such uncertainties can be major as shown by the selected examples.

4. This is generally not considered by the scientific community currently working on these issues.

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



Model 1	Model 2	Model 3
- Geographical Attachment	- Geographical Attachment	-
- Environment	-	- Environment
- Population size	- Population size	- Population size
- Population Demography	- Population Demography	- Population Demography
- Population Memory	- Population Memory	- Population Memory

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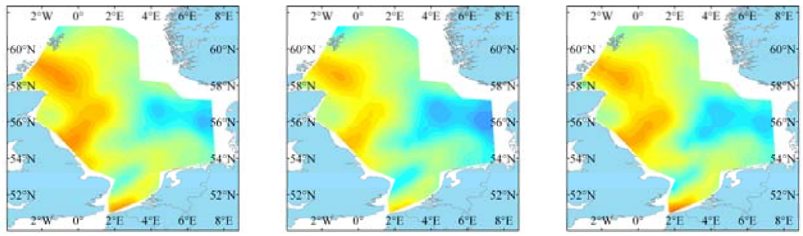
An example of uncertainty in the conceptual model

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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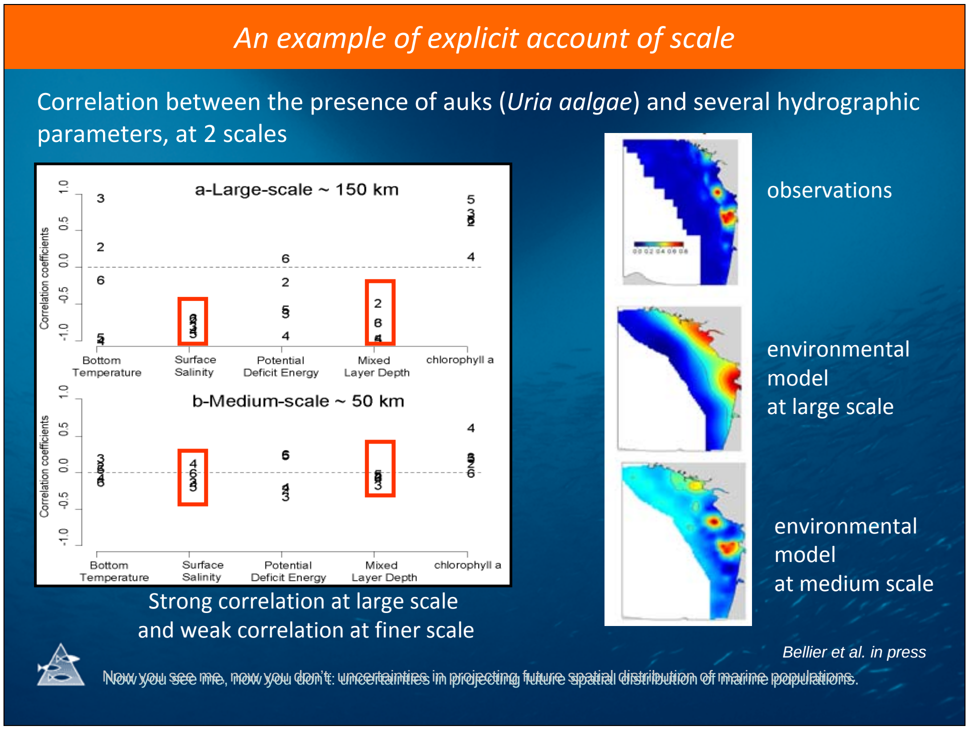
An example of explicit account of scale
Correlation between the presence of auks (*Uria aalgae*) and several hydrographic parameters, at 2 scales
a-Large-scale ~ 150 km
Correlation coefficients
Bottom Temperature
Surface Salinity
Potential Deficit Energy
Mixed Layer Depth
chlorophyll a
b-Medium-scale ~ 50 km
Correlation coefficients
Bottom Temperature
Surface Salinity
Potential Deficit Energy
Mixed Layer Depth
chlorophyll a
Strong correlation at large scale
and weak correlation at finer scale
observations
environmental model at large scale
environmental model at medium scale
Bellier et al. in press
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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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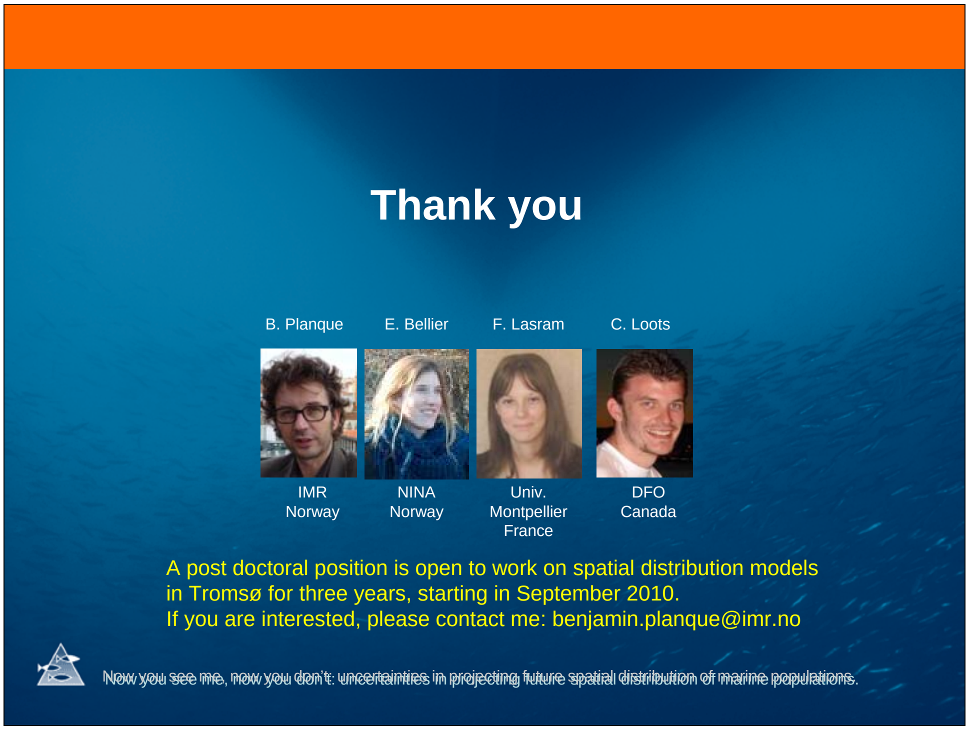
Thank you
B. Planque
E. Bellier
F. Lasram
C. Loots
IMR
Norway
NINA
Norway
Univ.
Montpellier
France
DFO
Canada
A post doctoral position is open to work on spatial distribution models
in Tromsø for three years, starting in September 2010.
If you are interested, please contact me: benjamin.planque@imr.no
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