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The effect of ageing errors on Von Bertalanffy parameters estimation using a Bayesian sensitivity analysis approach

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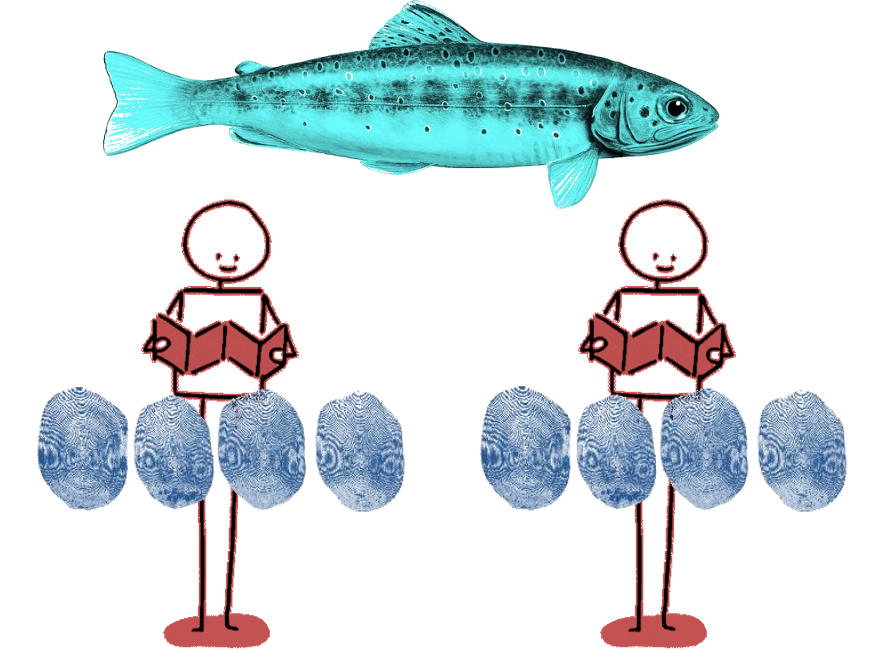


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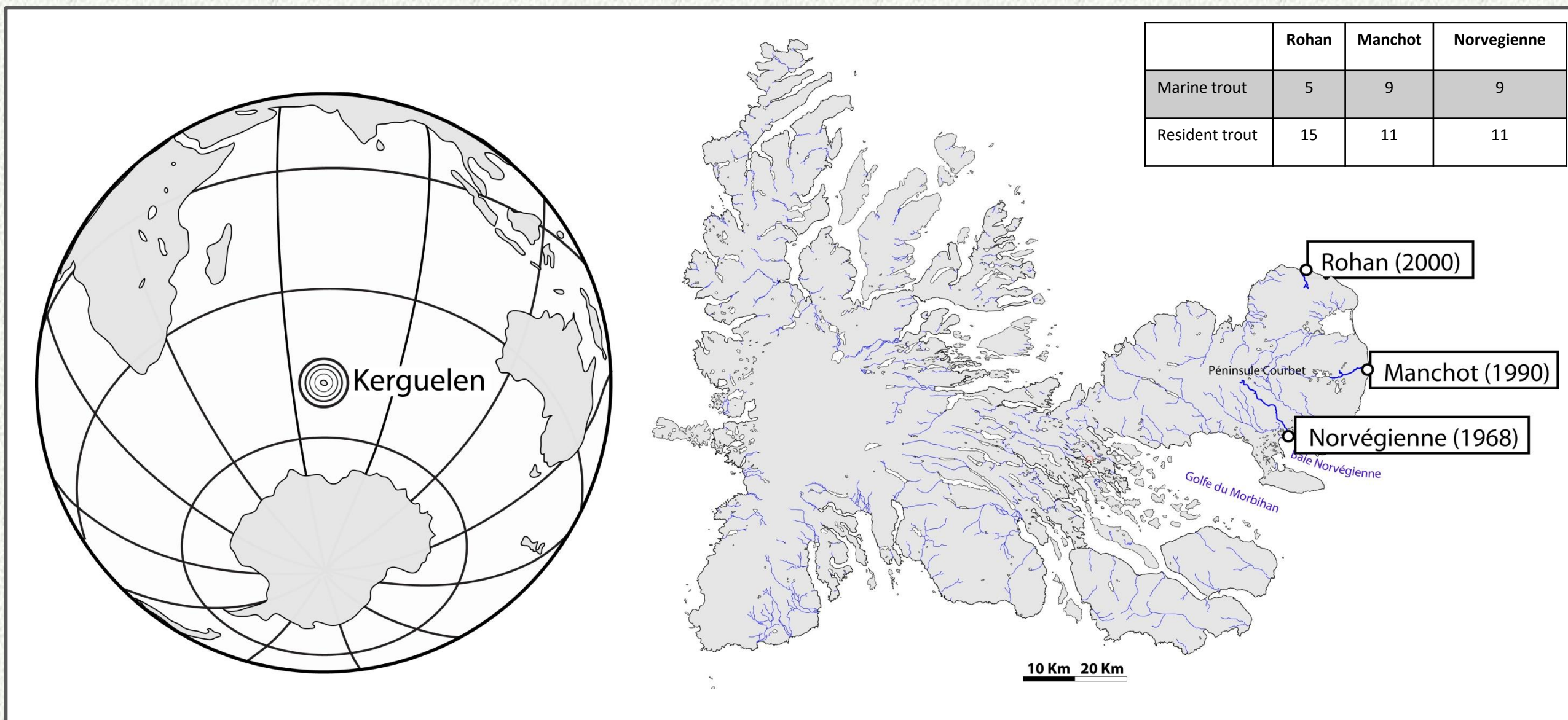
Context

The analysis of age and growth information contained in the **scales of fish** has become a standard technique in fish population dynamics model. Commonly modeled using Von Bertalanffy growth function (VBGF), inferring growth for fish is dependent upon an accurate description of the age-length relationship, which may be undermined by ageing errors. Ageing errors frequently arise either from disagreements between scales, readers or inability of scales to reflect true age (i.e. erosion, false growth ring). Here we use a Bayesian approach to infer *Salmo trutta* (L.) VBGF's parameters from scale samples. Inferred from scale readings of 60 fish, age at capture (for all fish) and age at migration (for the anadromous fish) were extracted based on a hierarchical design with blind double reading using 4 scales per fish. We estimated VBGF's parameters under different parametrization in the number of scales and reader per fish.

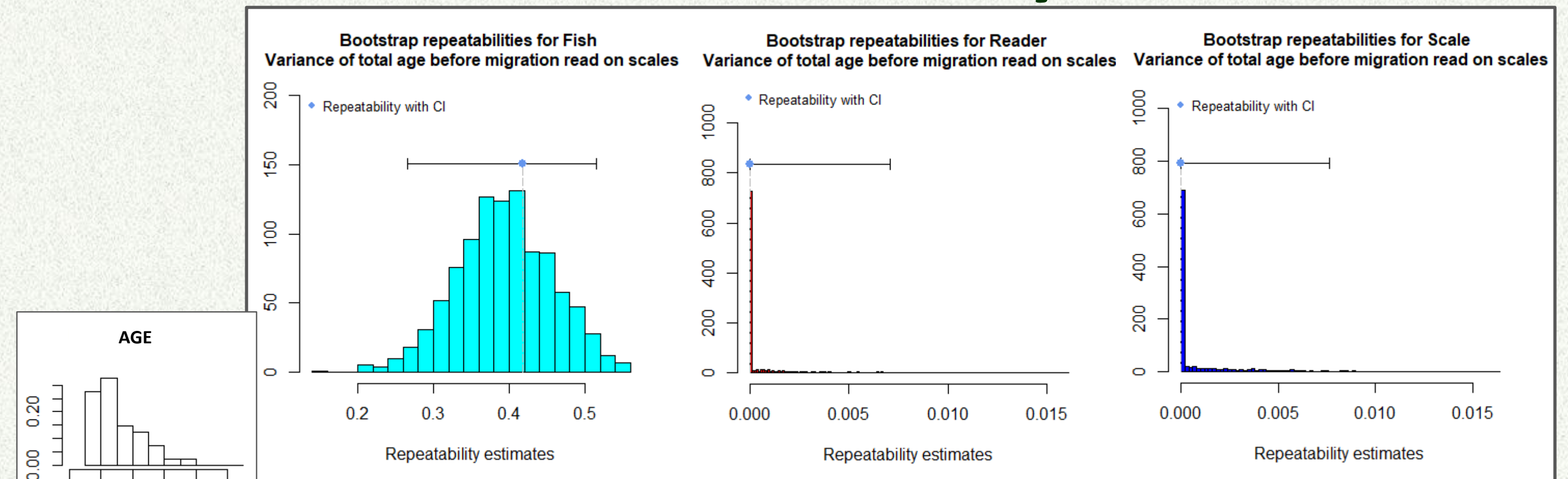
Hierarchical design (Nested sampling)



Localization

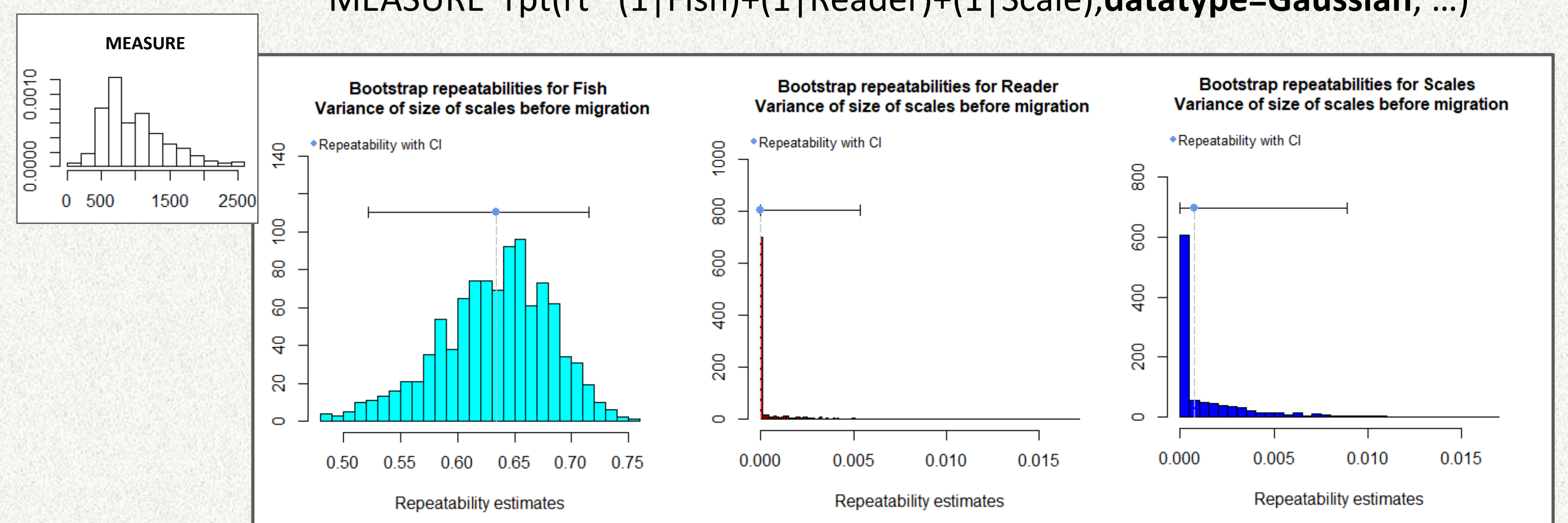


Variance analyses



$$AGE \sim rpt(\text{age} \sim (1|Fish) + (1|Reader) + (1|Scale), \text{datatype}=\text{Poisson}, \dots)^*$$

$$MEASURE \sim rpt(\text{rt} \sim (1|Fish) + (1|Reader) + (1|Scale), \text{datatype}=\text{Gaussian}, \dots)^*$$



Models

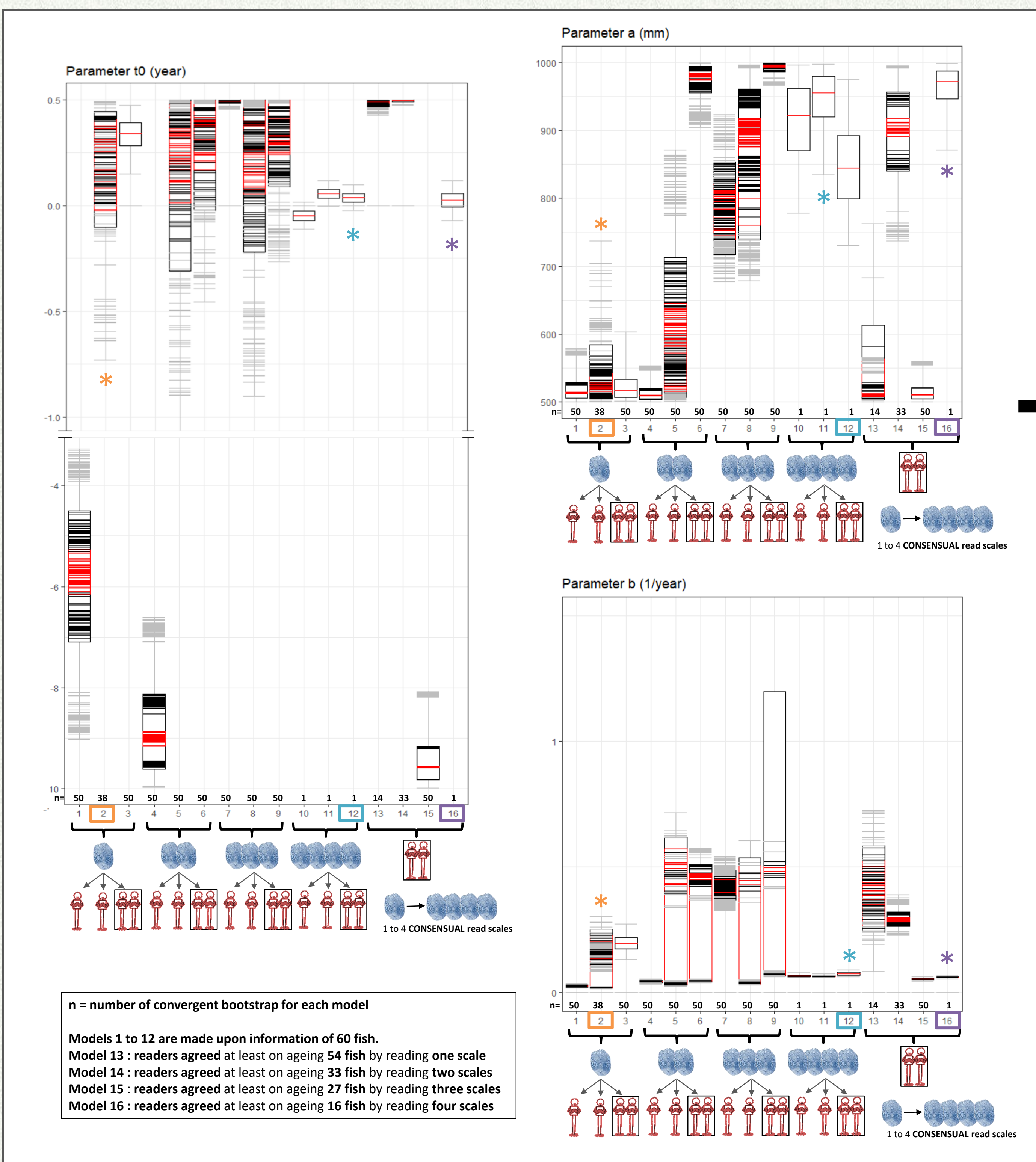
$$L_{i,t} = L_{\infty i} + e^{-K_i(t_i - t_0)}$$

$$L_{\infty i} = a + \varepsilon_{1i}, \quad a \sim \text{dunif}(500, 1000)$$

$$K_i = b + \varepsilon_{2i}, \quad b \sim \text{dnorm}(0.6, 0.001)$$

$$t_0 \sim \text{dunif}(-10, 0.5)$$

Results



Random selection of one scale read by one reader → More variation in approximating the parameters of VBGF growth function but similar average size-at-age compared with models with two readers and four scales.

Complete dataset (model 12) versus consensual dataset (model 16) on four scales → same average result and variation around the mean curve → individual effect of growth. Determination of the VBGF's parameters is more precise for consensual dataset.

Age accuracy can be proven or estimated with methods such as capture-mark-recapture (CMR). Agreement in the age determination between reader (consensual readings) is a selection of fish for which precision is 100% but it does not mean that the determination is accurate and represents the entire population. **

Sources of variance in the age determination should be investigated before any results interpretation. By doing so, we can empirically determine the robustness of VBGF's parameters at a population scale in our study. *** Going further, variance on age should be integrated at the individual level.

* Stoffel, M. A., Nakagawa, S. and Schielzeth, H. (2017). rptR: repeatability estimation and variance decomposition by generalized linear mixed-effects models. *Methods Ecol Evol*, 8: 1639-1644.

** Beamish, R. J., et G. A. McFarlane. « The Forgotten Requirement for Age Validation in Fisheries Biology ». *Transactions of the American Fisheries Society* 112

*** Cope, Jason M., et André E. Punt. « Admitting ageing error when fitting growth curves: an example using the von Bertalanffy growth function with random effects ». *Canadian Journal of Fisheries and Aquatic Sciences* 64, no 2 (1 février 2007): 205-18.