Investigations of daily and annual increment deposition rates in otoliths and their usefulness for estimation of the age and growth of fish

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Asking the Right Question

~~Are annual rings better than daily rings?~~

What is the best ageing protocol for my fish stock?

An Ageing Protocol

Includes

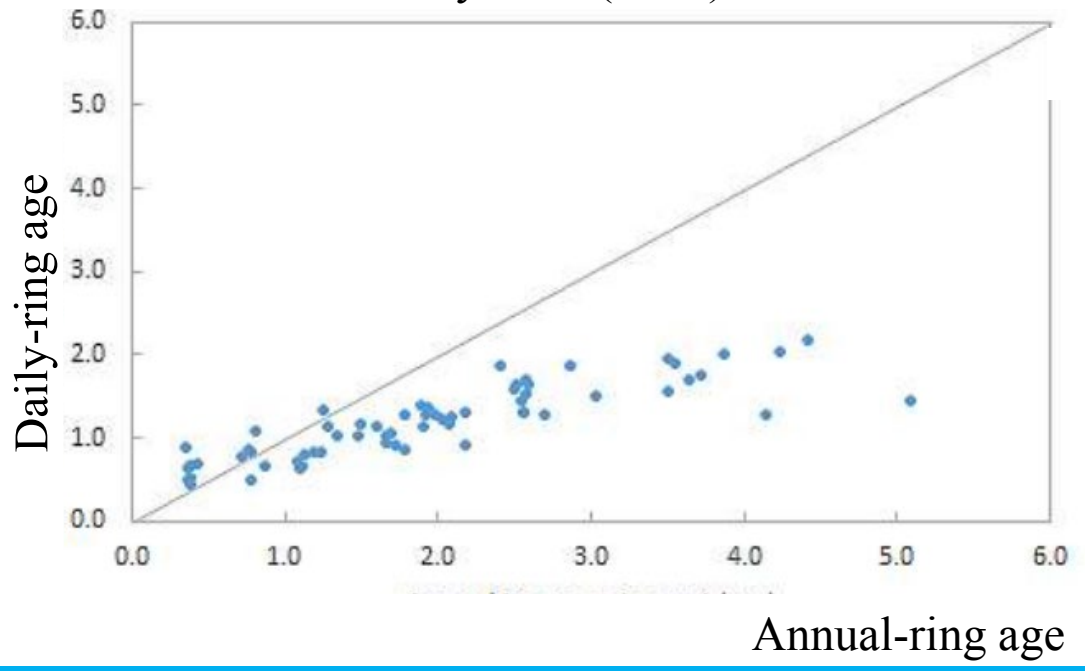
- Choice of annual or daily rings
- Method of otolith preparation
- Ring identification (what to count)
- If annual, how to convert ring count to age

All these elements affect the usefulness of a protocol

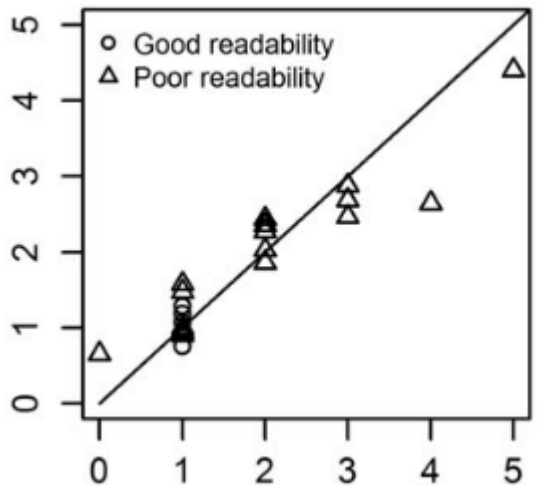
A protocol that works well for one stock may be poor for another

Daily- vs Annual-Ring Ages for WCPO BIG

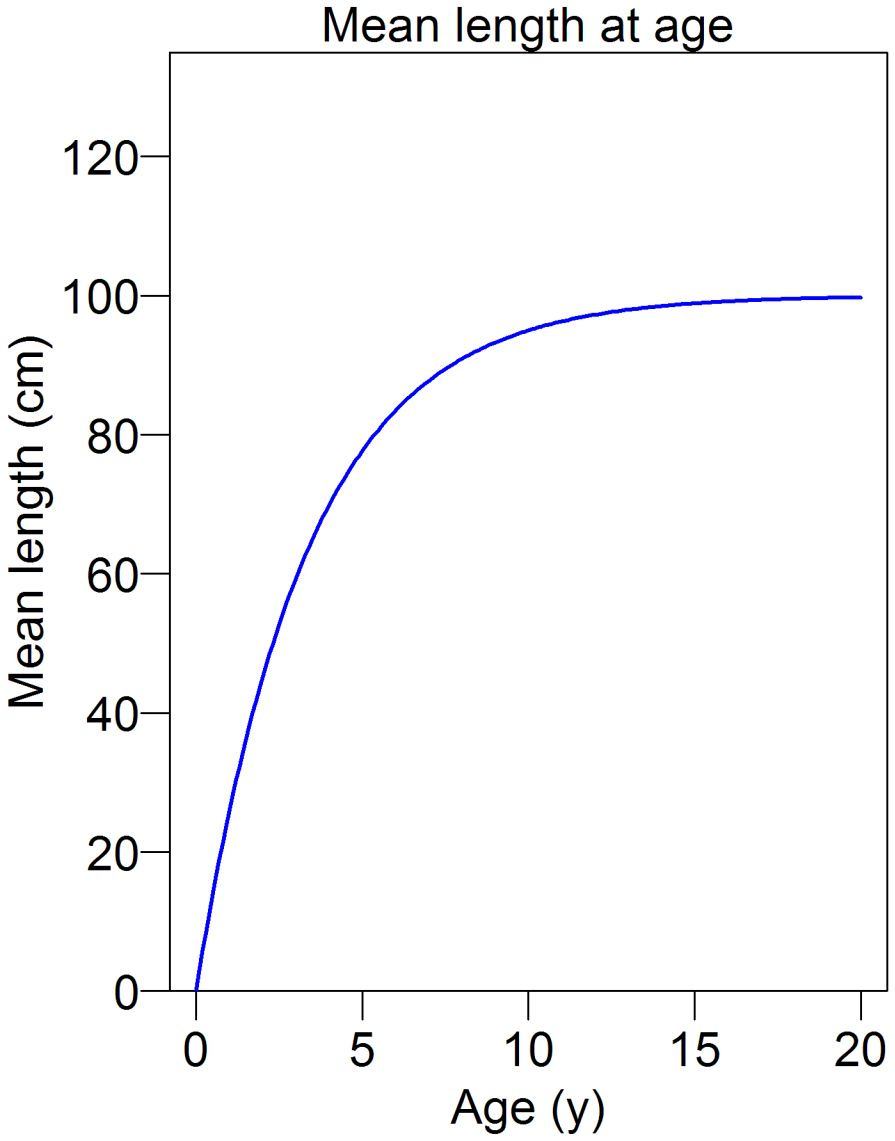
Farley et al. (2017)

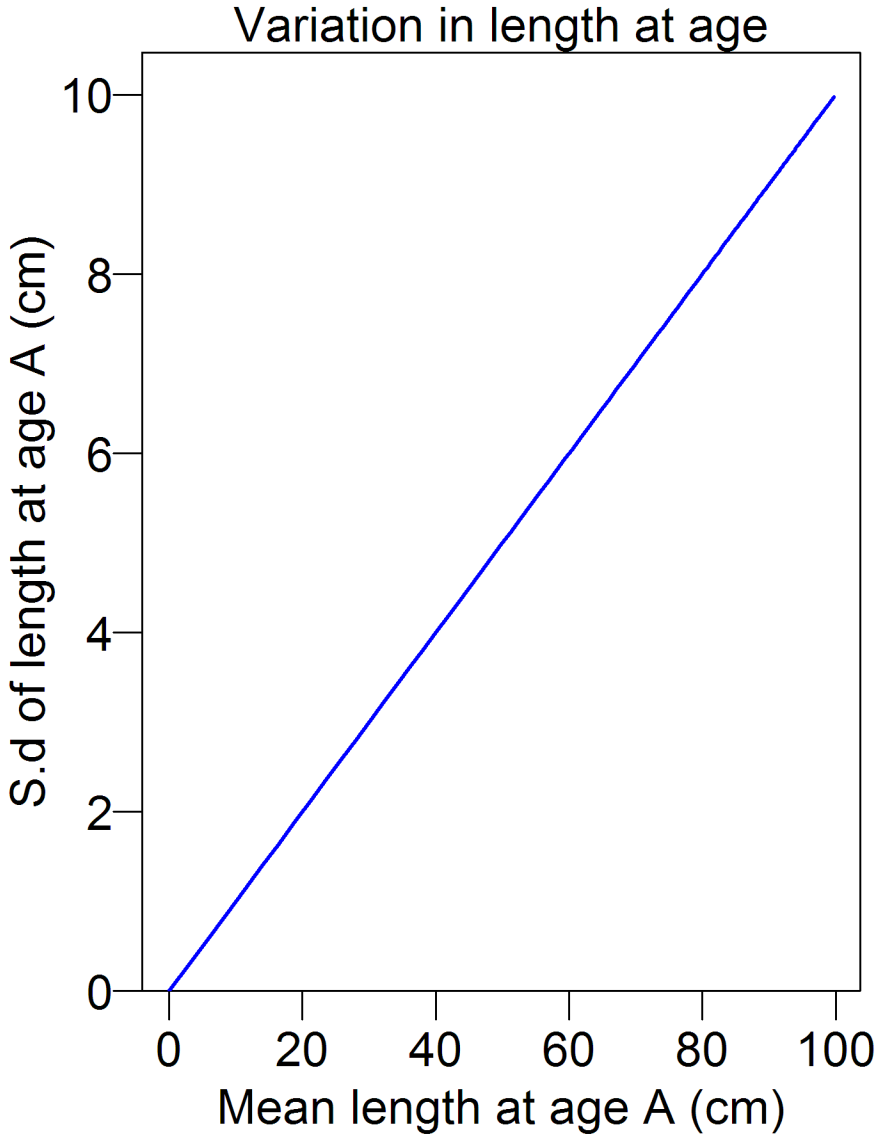


Williams et al. (2013)



A Stock Assessment Growth Model





Variation just as important as Mean

Particularly true for tuna stock assessments (because of heavy dependence on length comps)

The influence of L_∞ on a stock assessment will depend on the variation component

The two components should be independent when a growth model is fitted to observations

Common forms of growth variation

Most common forms are

$$\text{c.v.}(L \mid A) = a + b\bar{L}_A$$

$$\text{s.d.}(L \mid A) = a + b\bar{L}_A$$

where $\bar{L}_A = \text{mean}(L \mid A)$

In Multifan-CL

$$\text{s.d.}(L \mid A) = a + \exp(b\bar{L}_A)$$

What do we mean by Validation?

Question: What do we mean when we say that an ageing protocol is validated?

Rough answer: There is evidence that it produces age estimates that are, on average, approximately correct

Better answer: There is evidence that it produces age estimates that have small bias

Best answer: There is evidence that it produces age estimates for which bias is likely to be less than *x*%

Statistical View of Validation

Typically approached as **hypothesis testing**:

- null hypothesis: the ageing protocol is valid (i.e. unbiased)

Often not very satisfactory:

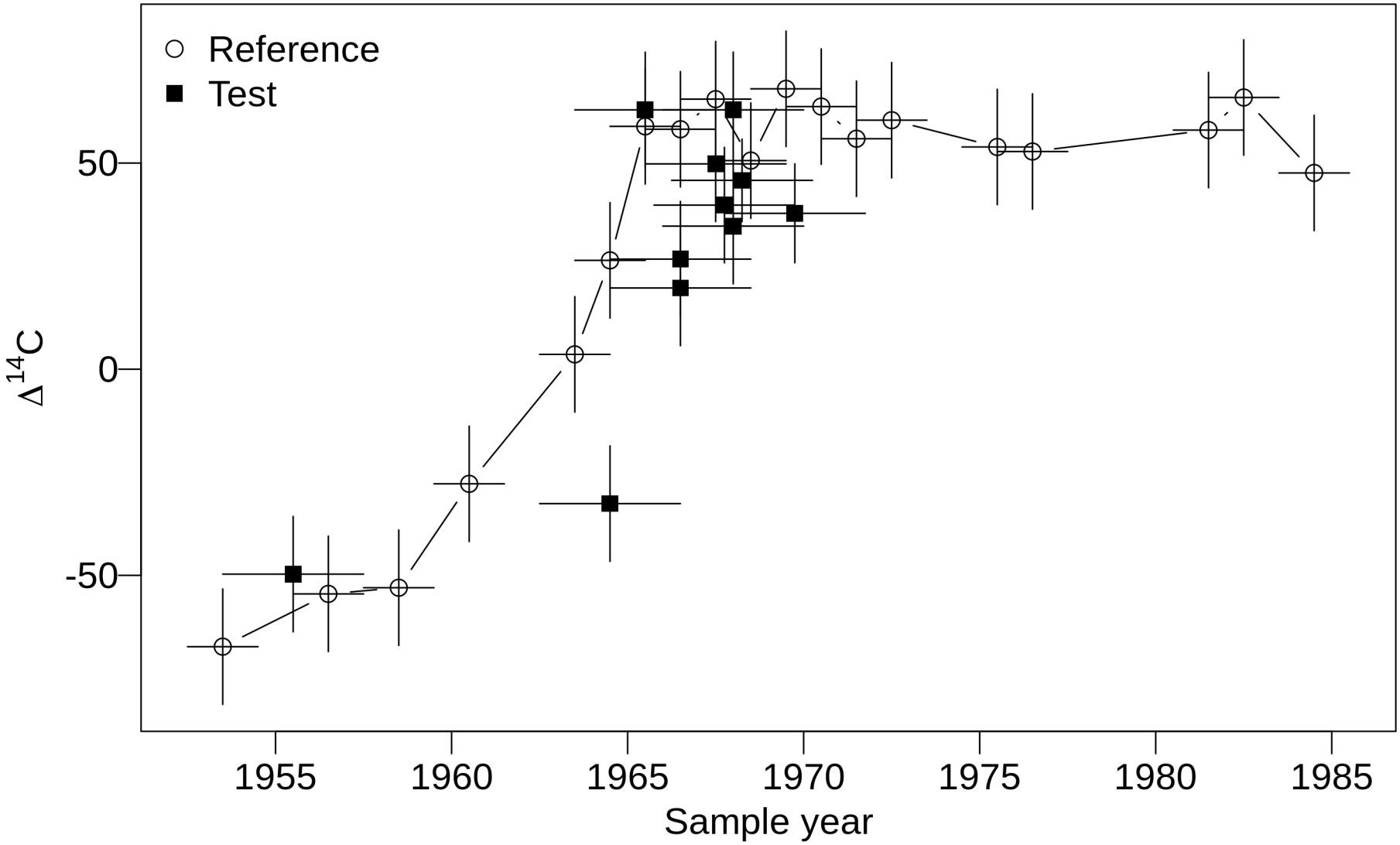
- testing is informal (a subjective decision, often from a graph)
- only two outcomes:
  - the protocol is validated or not validated
- no evaluation of the power of the test
  (how biased could the validated protocol be?)

Something to aim for:

validation as **bias estimation**, rather than hypothesis testing
(e.g., for bomb-carbon, CJFAS 67: 1398-1408, 2010)

Question to consider: What levels of bias does your validation rule out?

Bomb-carbon Validation

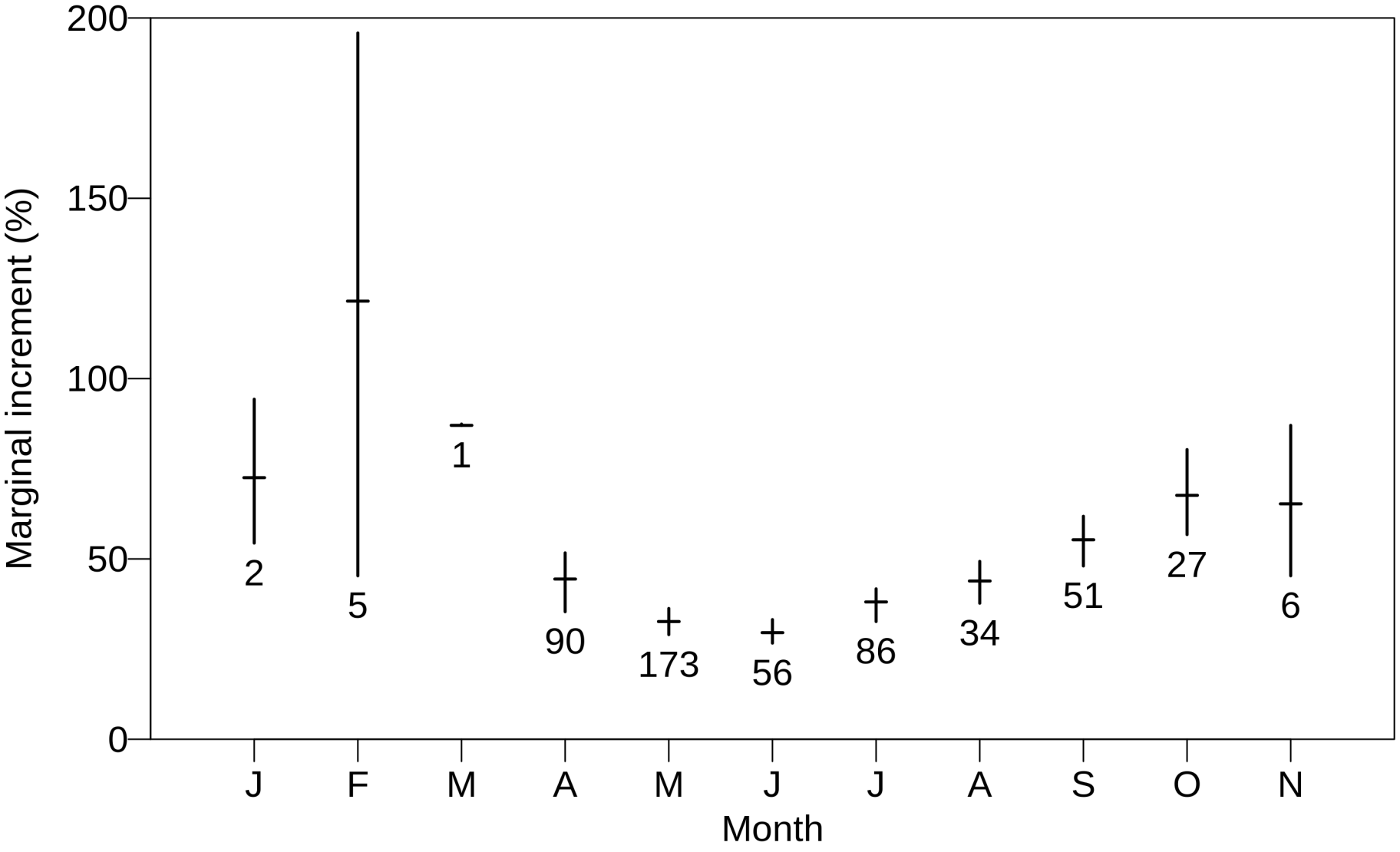


Questions to ask about Graphical Validations

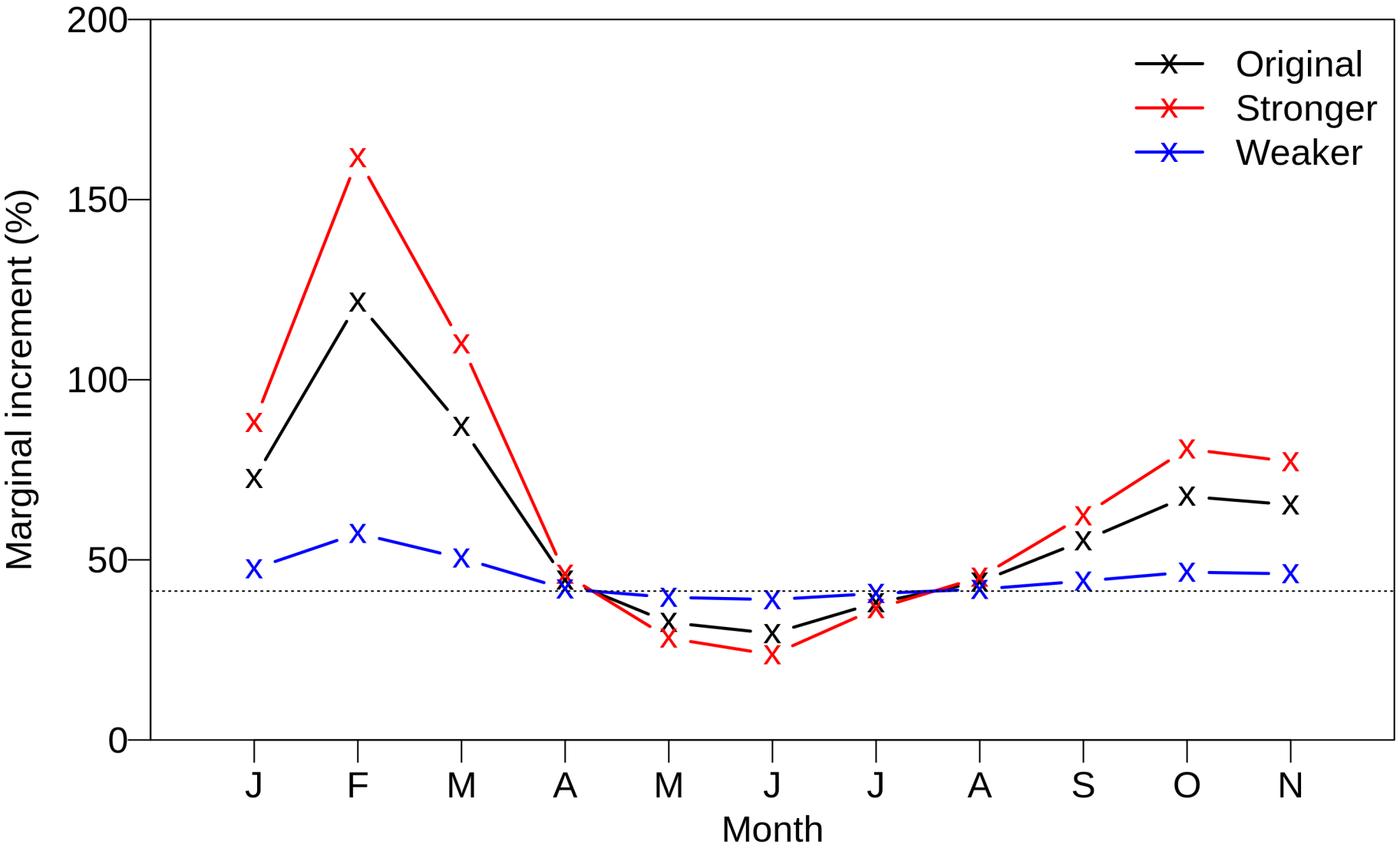
What would the graph have to look like for the validation to fail?

What sorts of ageing errors are consistent with this graph?
(i.e., how strong is this validation?)

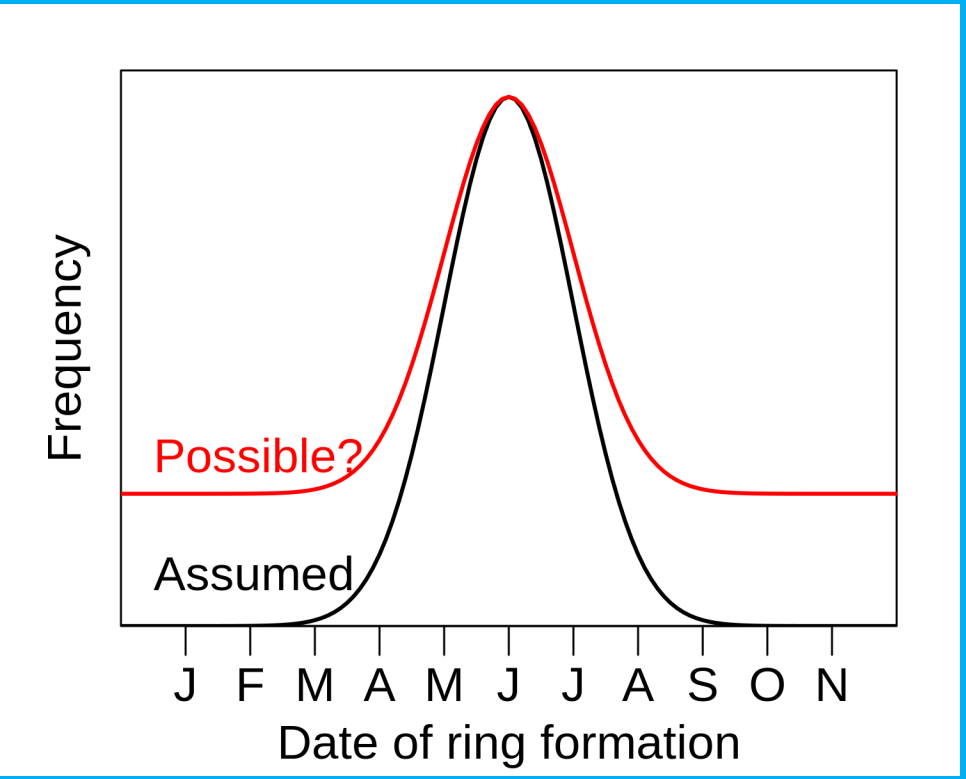
Marginal Increment Validation



Strength of Validation



Some Possibilities

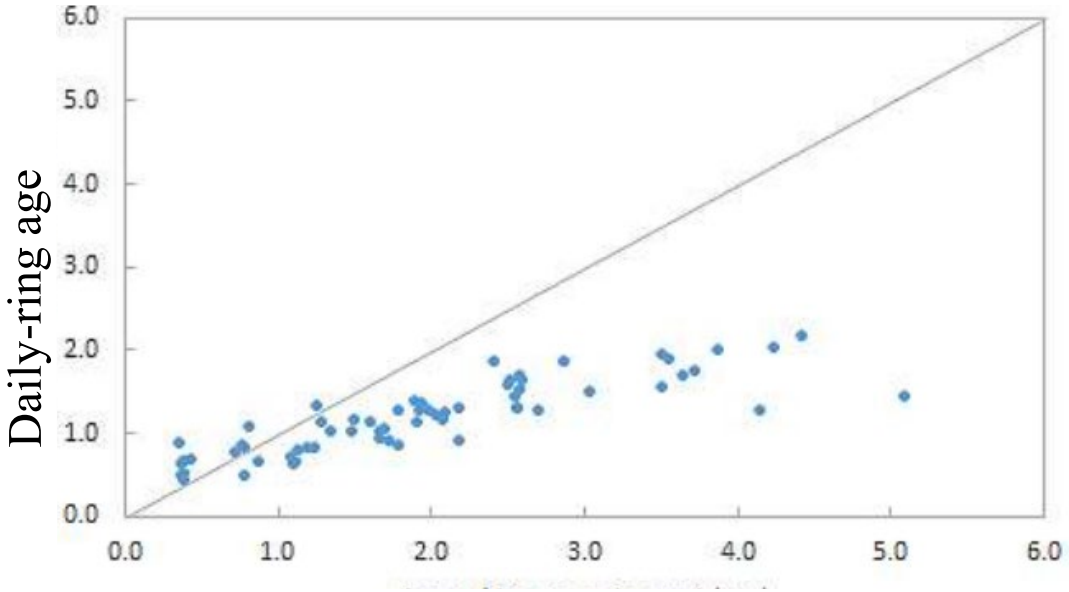


Perhaps rings form annually in mid-year, but 10% of them are not counted?

… or ring counts are inflated 10% by false rings?

Can we use tagging data to validate ageing?

Idea: - Fit single growth model to age-length and tagging data
- Check model diagnostics for consistency between data sets
- e.g., Eveson et al (2015, Fish. Res. 163: 58-68)

Or: - Fit growth model to tagging data alone
- Check for model consistency with age-length data

Farley et al. (2017)