

# The a4a stock assessment model – a nonlinear mixed effects model in FLR/R with an interface based on linear and additive model formulae

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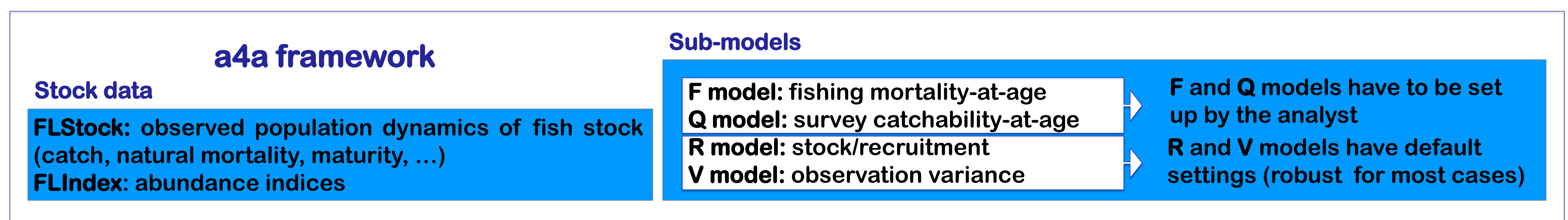
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## Introduction

a4a is a new statistical framework for age-based fish stock assessment implemented as an R library called FLa4a that uses existing data structures and functions in the Fisheries Libraries in R (FLR) library. The framework was designed to be flexible in terms of model structure, able to provide robust results quickly, while also being easy to use. The framework was developed under the scope of the "assessment for all" (a4a) initiative of the European Commission Joint Research Centre, which is designed to extend the application of stock assessment models and forecasting to a growing number of data-moderate fish stocks and eventually to all fish stocks in a sea basin or ecosystem, exploring the benefits arising from using a unified coherent assessment framework.

## Methods

Utilizing existing powerful model specification tools in the statistical software environment R, in particular the linear and additive model formula interfaces, the model provides flexibility and ease of use, giving access to a wide variety of established modelling tools. The fast and robust fitting is achieved by using an automatic differentiation based optimiser written in C++ (ADMB), which also provides estimates of the parameters' statistical properties.



## Case study: North Sea Cod

For the first part of the case study we fit a basic model.

```
fmodel1 <- ~factor(age) + factor(year) # fmodel is an intercept and slope for age and year
qmodel <- list(~factor(age)) # survey catchability at age without year trend
fit1 <- a4a(fmodel1, qmodel, stock = stk, indices = idx) # stk=FLStock; idx=FLIndex
```

Turning now to the second section we keep the qmodel the same as before, but we change the fmodel using different smoothers and interactions between age and year

```
fmodel2 <- ~s(age, k=4) + s(year, k=7) # fmodel is a thin plate spline over age and year
fmodel3 <- ~year * age # fmodel with interactions between year and age
fmodel4 <- ~factor(age) + s(year, k=14) # fmodel is an intercept and slope for age and a thin plate spline over year
```

We now fit the models with the new fmodels and have a look at the AIC, BIC, degrees of freedom and the plot of the results.

```
fit2 <- a4a(fmodel2, qmodel, stock=stk, indices=idx)
```

```
stk2 <- stk+fit2
```

plot(stk2)	Submodel	df	AIC	BIC
AIC(fit1, fit2, fit3, fit4)	1 fmodel1	125	332.7042	889.4073
	2 fmodel2	77	549.5800	892.5091
	3 fmodel3	71	807.6660	1123.8734
BIC(fit1, fit2, fit3, fit4)	4 fmodel4	90	395.8580	796.6842

## Conclusions

The a4a model, when compared to other stock assessment models, provides the user with both ease of use and sufficient flexibility, while obtaining robust results. The setup of the model permits a wide variety of sub-model implementations with just a few lines of code. Moreover, the analyst can then compare the results of the different stock assessments using a number of provided plots and diagnostics.

## References

<https://fishreg.jrc.ec.europa.eu/web/a4a/>  
R Development Core Team (2013) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>. ISBN 3-900051-07-0.  
Kell LT, Mosqueira I, Grosjean P, Fromentin JM, Garcia D, et al. (2007) FLR: an open-source framework for the evaluation and development of management strategies. ICES Journal of Marine Science: Journal du Conseil 64: 640–646.  
Fournier D, Skaug H, Ancheta J, Ianelli J, Magnusson A, et al. (2012) AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex non-linear models. Optimization Methods and Software 27: 233–249.

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