Welcome to
AD Model Builder and Stock Assessment

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Course outline

L	Welcome and Introduction
L/E	A first simple model
L	Likelihood based inference
E	(Extended) linear regression
L/E	Non-linear regression
L	Biomass model
E	Using a control file
L	Coleraine demo
L/E	Simple Statistical Catch at Age model
L/E	Bayesian models and Priors
L/E	Quantifying uncertainties (MCMC/profile)
L/E	Linear mixed effects models
L	General random effects models
E	Uni-variate state-space models
L	Multivariate state-space models
L/E	The state-space stock assessment model (SAM)

Introductions

Instructors

- Anders Nielsen (Technical University of Denmark, DTU-Aqua)
- Arni Magnusson (Marine Research Institute of Iceland)

With a lot of help from

- Johnoel Ancheta (Pelagic Fisheries Research Program, PFRP)
- Mark Maunder (Inter-American Tropical Tuna Commission, IATTC)
- John Sibert (Pelagic Fisheries Research Program, University of Hawaii)

Please introduce yourselves

- Name and Organization
- Your research and what you would like to do with ADMB?

What is AD Model Builder?

- A tool for building models and challenging them with data.
- Enables efficient estimation of model parameters.
- Consists of a template language, similar to a fourth-generation computer language.
- Includes template processor and support library containing:
  - A quasi-Newton minimizer aided by automatic differentiation
  - Tools for reading in most interesting data objects (number, vector, matrix, 3darray, ragged arrays, strings, ...)
  - Tools for specifying model parameters (unbounded, bounded, fixed, summing to zero, vectors of, matrix of, ...)
  - A simple way to set up optimization in phases
  - Easy access to standard ways to quantify uncertainty (Hessian based delta method, profile likelihood, MCMC sampling)
  - Tools for handling random effects (AD aided Laplace approximation, sparse matrix, importance sampling, ...)
  - Helpful functions (gammaln, choleski_decomp, inv, det, eigenvalues, RNG, ...)

ADMB Simplifies model development

- Manages description and input of data.
- Manages description of model parameters and objective function.
- Manages the interface between model parameters and numerical function minimizer.
- Includes for describing and estimating model uncertainty.
- Vector and matrix operators.
- C++ implementation allows creation of complex data stuctures and use of specialized libraries.

Efficient estimation of model parameters

- ADMB Minimizer uses analytically correct partial derivatives of objective function.
- Parameters may be estimated in user-specified order — estimation "phases" .
- Bounds may be imposed on all parameters.

MCMC algorithm

- Starts at the mode of the posterior distribution to reduce "burn-in" time.
- Jumping rules based on the covariance matrix at the mode of the posterior distribution.
- Enables rapid and accurate Bayesian integration.

Random effects parameters

- Uses Laplace approximation (and possibly importance sampling).
- Analytically correct third derivatives.
- Adaptable for process error and meta analysis.

What is it used for?

- Not enough
- Our web-site lists (at my last count):
  - 110 peer reviewed publications based on AD Model Builder applications
  - 18 Theses and Dissertations
  - Countless reports and fish stock assessments
- Those are only the users who remembered to report back
- Models in fisheries science are typically:
  - Non-standard
  - Non-linear
  - High dimensional
- Often they also contain random effects
- They should preferably run in minutes

Dave Fournier receiving the AFS Ricker award

What is the AD Model Builder Foundation

- AD Model builder was developed by Dave Fournier
- The random effects part was developed by Dave and Hans Skaug
- AD Model Builder Foundation is a non-profit organization
- Informally founded at Tuna Camp 2007
- From a discussion of how to keep AD Model Builder (or alternatives) available
- Because AD Model Builder is used in hundreds of journal papers and numerous standard models we agreed to stay with that
- Obtained a generous grant from the Gordon and Betty Moore Foundation to NCEAS[a] to buy the software.
- Its goal is to make AD Model Builder freely available and open source
- Aims to widen the user group, and establish a group of developers

[a] National Center for Ecological Analysis and Synthesis at the University of California