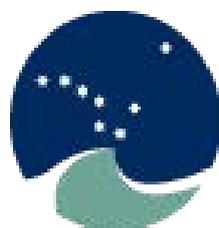


# ICES TCMDFSA 2015 REPORT

## Report of the Training Course: Model Development in Fish Stock Assessment (ADMB, TMB, and SAM) (TCMDFSA)

2–6 November 2015



**ICES**

International Council for  
the Exploration of the Sea

**CIEM**

Conseil International pour  
l'Exploration de la Mer

**International Council for the Exploration of the Sea  
Conseil International pour l'Exploration de la Mer**

H. C. Andersens Boulevard 44–46  
DK-1553 Copenhagen V  
Denmark  
Telephone (+45) 33 38 67 00  
Telefax (+45) 33 93 42 15  
[www.ices.dk](http://www.ices.dk)  
[info@ices.dk](mailto:info@ices.dk)

Recommended format for purposes of citation:

ICES. 2015. Report of the Training Course: Model Development in Fish Stock Assessment (ADMB, TMB, and SAM) (TCMDFSA) 2–6 November 2015. 14 pp.

The document is an ICES Training Course report.

© 2016 International Council for the Exploration of the Sea

## Contents

---

Summary.....	1
Recommendations.....	2
Course description .....	3
Course Programme and Instructors .....	4
Annex 1: List of participants.....	5
Annex 2: Detailed course programme .....	6
Annex 3: Results of course evaluation questionnaire.....	8



Participants at the course “Model Development in Fish Stock Assessment (ADMB, TMB, and SAM)” conducted 2–6 November 2015 at ICES Headquarters in Copenhagen. The course was given by Arni Magnusson and Anders Nielsen (sitting in front).



Report of the ICES training course:  
“Model Development in Fish Stock Assessment  
(ADMB, TMB, and SAM)”

by

Anders Nielsen and Arni Magnusson

## Summary

---

This was a new course, based on a previous course (AD Model Builder and Fish Stock Assessment, TCADSAM) that ICES offered in 2011 and 2013.

AD Model Builder (ADMB) and Template Model Builder (TMB) are two related programming environments. Both environments are designed to meet the requirements posed by typical stock assessment models that are nonlinear, highly parameterized, and may have time-varying parameters. The performance of ADMB (introduced in 1993) and TMB (2013) is similar for basic models, but starts to diverge with more complex models, where TMB models are easier to develop and run faster. The TMB workflow is closely linked with R, which is a practical advantage since R is widely used by stock assessment experts.

A few weeks before the workshop, a decision was made in agreement with the participants, to present only a brief overview of ADMB on the first morning but focus the course on TMB. For the instructors this meant a lot of work, converting presentations and exercises from ADMB to TMB. The programming syntax is different and the challenges facing a new user are also different, so the conversion was not straightforward. Several exercises were also improved and extended.

State-space Assessment Model (SAM) is a general model that is currently used in the assessment of several stocks in the ICES area. It models time-varying selectivity and recruitment using random effects, in a statistically efficient way. When SAM is used as the basis for management advice, it is important that the stock coordinator understands not only how to run the model, but also the underlying statistical theory and model processes.

The course introduced modelling concepts and techniques in a continuous gradient, starting with simple linear models before moving to nonlinear models. Going through biomass-dynamic and statistical catch-at-age models, the maximum likelihood approach was used as the basis of fitting models and evaluating uncertainty about quantities of interest, such as current biomass and harvest rate. The second half of the course focused on random effects as a general statistical approach, first in simple applications and then adding random effects to a basic assessment model from an earlier exercise. Finally, the SAM user interface and model settings were described, and a full assessment model run analyzed.

Practical exercises formed the backbone of the course, with statistical theory and modelling techniques introduced when they were actually needed for the practical analysis. Since the statistical and computational background of the participants varied considerably, the exercises were designed so that everyone could complete and understand the essential part of the analysis, but more advanced participants could explore related statistical issues as well.

On the last day, many participants were applying TMB to analyze data from their own stock assessment work, which reflects that the course was a successful one. The training course evaluation was generally very positive (Annex 3) and many participants said the course helped them to master concepts and techniques that they had struggled with in previous and ongoing stock assessment work.

## Recommendations

---

The monitor in the Atlantic conference room is a great asset for teaching, but it proved challenging to connect the instructor laptops to the monitor. A workshop like this one uses too many statistical software applications to install everything on the conference room desktop computer. Like an increasing number of participants, the instructors use the Linux operating system. In the end, it was possible to connect one of the instructor laptops (Ubuntu Linux), but not the other instructor's laptop (CentOS Linux). This problem could be solved with a simple direct cable, so all computers can connect to the monitor. This would have improved the lectures and demonstrations, so we recommend that ICES IT staff provide a simple cable connection for the monitor, to cover all edge cases.

TMB is relatively new software environment, and at the time of the workshop the support for the Windows platform was slightly limited, compared to Linux. Compiling models took much longer in Windows, and debugging facilities were missing. Therefore, the instructors had prepared a Linux virtual machine as one option to install TMB and supporting tools on any computer. Overall, this experiment was a mixed success. On the positive side, the virtual machine allowed everyone to get up and running very quickly on the first morning, compile models fast, and the debugging facilities helped participants fix errors in their model code. On the negative side, the virtual machine created a gap between TMB and the environment that the participants use in their daily work, and technical glitches interrupted the workflow, which may have been related to configuring the time zone in the virtual machine to match the host computer. At any rate, TMB support for Windows has improved now, just weeks after the workshop, so in a future TMB workshop we will probably not recommend using the virtual machine to install TMB. Nevertheless, virtual machines are an innovative solution that will likely be used in educational settings in one form or another, within and outside ICES training courses.

Written feedback comments from workshop participants show that some found the overall pace too fast, while others would have wanted more time spent on the most advanced topics (state-space models). If the workshop was slightly too fast for some and slightly too slow for others, then that indicates that we achieved the middle ground that we were aiming for. Some comments ponder on the diverse background of the participants and conclude that the course had a good balance in this regard.

On a related note, some commented on the varying difficulty of exercises. That is something we designed on purpose: the exercises related to fundamental topics (which are later built on) were easy enough so everyone completed them, while a few shorter exercises on special topics were only successfully completed by those with a stronger background. For the others, it served as a short 'advertisement' that this topic exists and how it relates to the more fundamental topics. In the easier core exercises, we gave participants a relatively long time to solve the task, so they could gain experience and confidence to build on it. Also during these longer exercises, participants would often raise an interesting point that turned into a discussion that the group engaged in, addressing current topics in stock assessment methodology.

One comment suggests a clear flowchart regarding the exercises. The relationship between exercises was clear in the minds of the instructors, and when introducing a new exercise we verbally explained how it related to the previous and following exercises. However, presenting a visual and complete flowchart of exercises, and introducing it at the beginning as a roadmap, is a great idea that we will use next time we teach a TMB workshop.

Following a tradition from the ADMB workshops (TCADSAM 2011 & 2013) we archived the entire teaching material in one compact bundle called Everything.zip. This file has now been uploaded to the course website.

## Course description

---

### Objective

The objective of the course is to guide participants in developing stock assessment models, explaining the key differences between deterministic processes, stochastic models, Bayesian models, and state-space models.

Model development is demonstrated in two related programming environments: AD Model Builder (ADMB) and Template Model Builder (TMB). Both environments are designed to meet the requirements posed by typical stock assessment models that are nonlinear, highly parameterized, and may have time-varying parameters.

After going through biomass-dynamic models, parametric age-structured models and MCMC analysis, the focus will be on random effects and finally a State-space Assessment Model (SAM), which is used for several assessments within ICES. This is a full stochastic model that allows selectivity to vary gradually with time, using fewer model parameters than full parametric models.

By the end of the course, the participants will be able to:

- Build stock assessment models in TMB
- Modify existing TMB models

### Level

In this advanced course, participants are assumed to have a background in applied statistics and statistical computing. Specifically, some experience fitting nonlinear models to data (in stock assessment or elsewhere) and basic programming skills.

## Course Programme and Instructors

---

The five-day course is organized as a series of alternating exercises and lectures, with discussion sessions in between. See programme outline below and details in Annex 2.

Day		Topic
Monday	AM	Introduction to TMB Building a simple model
	PM	Linear regression Maximum likelihood
Tuesday	AM	Parameters and transformation Recruitment models
	PM	Growth models Splines
Wednesday	AM	Evaluating uncertainty Biomass models
	PM	Statistical catch-at-age models Mixed effects models
Thursday	AM	Random effects State-space models
	PM	Time-varying processes F and N as random effects
Friday	AM	SAM code review SAM user interface
	PM	Work on own data Q&A summary

### Instructors

Anders Nielsen, DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund Castle, Jægersborg Allé 1, 2920 Charlottenlund, Denmark

Tel: (+45) 35 88 34 54

Email: [an@aqua.dtu.dk](mailto:an@aqua.dtu.dk)

Arni Magnusson, Marine Research Institute, Skulagata 4, PO Box 1390, 121 Reykjavik, Iceland

Tel.: (+354) 575 2000

Email: [arnima@hafro.is](mailto:arnima@hafro.is)

## Annex 1: List of participants

### Training Course on Model Development in Fish Stock Assessment (ADMB, TMB, and SAM) Atlantic Room 2–6 November 2015

NAME	COUNTRY	E-MAIL
Arni Magnusson Instructor	Iceland	arnima@hafro.is
Anders Nielsen Instructor	Denmark	an@aqua.dtu.dk
Abdullah Al-Mamun	Bangladesh	mamunbau09@yahoo.com
Alejandro Yañez	Chile	alejandro.yanez@ifop.cl
Alfonso Pérez Rodríguez	Norway	perezra@imr.no
Carlos Patricio Montenegro Silva	Chile	carlos.montenegro@ifop.cl
Elisabetta Bee Morello	Italy	b.morello@ismar.cnr.it
Giulia Gorelli	Spain	gorelli@icm.csic.es
Jennifer Devine	Norway	jennifer.devine@imr.no
Maria Jose Zuñiga Basualto	Chile	mariazuba@gmail.com
Martin Dorn	USA	Martin.Dorn@noaa.gov
Mathieu Lundy	UK	mathieu.lundy@afbini.gov.uk
Matthew Supernaw	USA	matthew.supernaw@noaa.gov
Niclas Norrström	Sweden	niclas.norrstrom@his.se
Nicola Walker	UK	nicola.walker@cefas.co.uk
Nicolas Gutierrez	Uruguay	nicolas.gutierrez@msc.org
Nikolaos Nikolioudakis	Greece	ninikoliou@gmail.com
Piera Carpi	Italy	piera.carpi@gmail.com
Robert O'Boyle	Canada	betasci@eastlink.ca
Robert Young	Canada	robert.young@dfo-mpo.gc.ca
Ruben Verkempynck	Netherlands	ruben.verkempynck@wur.nl
Suman Barua	Bangladesh	sbarua123bd@gmail.com
T. Mariella Canales	Chile	mariella.canales@gmail.com

## Annex 2: Detailed course programme

**Training Course on  
Model Development in Fish Stock Assessment (ADMB, TMB, and SAM)  
Atlantic Room 2–6 November 2015**

<b>Monday, 2 November</b>	
9.00 – 10.00	Welcome; Introduction of participants and lecturers; Expectations
10.00 – 10.30	<b>Tea/Coffee</b>
10.30 – 11:30	Introduction to ADMB and TMB
11:30 - 13:00	Install and configure; Building a simple model
13:00 – 14:00	<b>Lunch</b>
14.00 – 15.30	Exercise: Linear regression and variations
15.30 – 16.00	<b>Tea/Coffee</b>
16.00 – 17.00	Maximum likelihood
17.00 – 18.00	Data objects; Input/output
18.00 – 20.00	Icebreaker
<b>Tuesday, 3 November</b>	
9.00 – 10.00	Matrix algebra; Diffusion model
10.00 – 10.30	<b>Tea/Coffee</b>
10.30 – 11.30	Parameter objects; Transformation
11.30 – 13.00	Exercise: Nonlinear models (recruitment)
13.00 – 14.00	<b>Lunch</b>
14.00 – 15.30	Exercise: Nonlinear models (growth)
15.30 – 16.00	<b>Tea/Coffee</b>
16.00 – 18.00	Splines
<b>Wednesday, 4 November</b>	
9.00 – 10.00	Evaluating uncertainty; Bayesian inference; MCMC
10.00 – 10.30	<b>Tea/Coffee</b>

10.30 - 12.30	Biomass models; Exercise
12.30 - 13.00	Debugging; Help resources
13.00 - 14.00	<b>Lunch</b>
14.00 - 14.30	Statistical catch-at-age models; Exercise
15.30 - 16.00	<b>Tea/Coffee</b>
16:00 - 18.00	Mixed effects models (LME, NLME)
<b>Thursday, 5 November</b>	
9.00 - 10.00	Random effects; Laplace approximation
10.00 - 10.30	<b>Tea/Coffee</b>
10.30 - 11.30	Exercise: Random walk
11.30 - 12.30	State-space models
12.30 - 13.00	Exercise: theta-logistic model
13.00 - 14.00	<b>Lunch &amp; Group photo</b>
14.00 - 15.30	State-space Assessment Model; Time-varying processes
15.30 - 16.00	<b>Tea/Coffee</b>
16.00 - 18.00	Exercise: F and N as random effects
18.15 - 22.00	Course dinner (optional, expenses to be covered by participants)
<b>Friday, 6 November</b>	
9.00 - 10.00	SAM code review; Web interface
10.00 - 10.30	<b>Tea/Coffee</b>
10.30 - 13.00	Exercise: SAM
13.00 - 14.00	<b>Lunch</b>
14.00 - 15.00	Course evaluation and discussion
15.00 - 15.30	<b>Tea/Coffee</b>
15.30 - 17.00	Work on own data; Q&A

### Annex 3: Results of course evaluation questionnaire

---

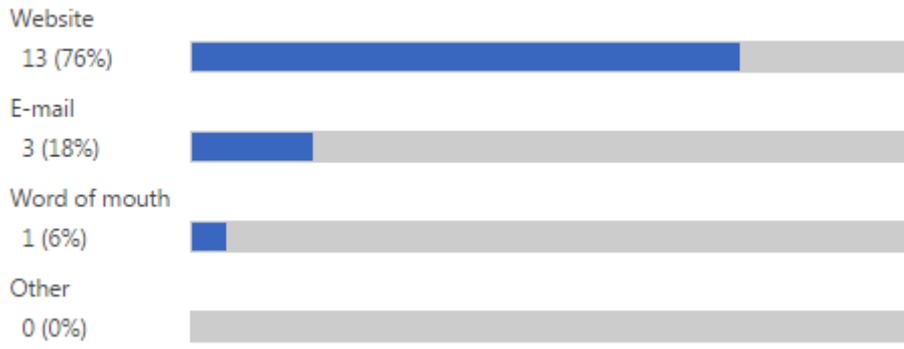
- This course is a must for scientists in the field of stock assessment. The main tool taught, TMB, is very new so and thus the course material and supporting material are under some development ( and will likely continue to be for a bit). I don't have suggested improvements which would be above and beyond what the instructors already no doubt are undertaking. Excellent course.
- The teaching staff was very helpful and willing to answer all the questions asked. However, I think clarity of presentations could be improved a little.
- Excellent presentations, exercises and explanations. One suggestion is to try to get the difficulty of the exercises more similar (or slowly increasing in complexity). Some exercises felt more complicated than other, later exercises. Good variety on the exercises though!
- A lot of material covered but it was introduced in a progressive order, explained very well and with useful exercises.
- Given the complexity of some of the concepts, it would have been useful to ground all the theory to specific examples; it has done for some concepts but not for others. Perhaps follow the same example (orange trees) throughout the course, simply adding complexity (when possible). Another suggestion would be to allow more time to work with our own data (easy to ground concepts when you know the data). Otherwise, I great course, with huge potential for application in a daily base. This type of classes are critical for fishery scientists in developing countries given the lack of specific courses on stock assessment modelling and coding. Thank you Arni and Anders!
- I really enjoyed the course and benefited from it many ways. The availability of instructors to help at all times was very important. One negative feature was that in some cases prior knowledge with respect to some of the contents of the course was taken for granted. Given the wide range of expertise of participants, and the fact that this was a known prior, this should have maybe been taken care of (either by selecting attendants beforehand or by making some of the content a little more clear and basic).
- Overall this was an excellent course with a good introduction to cutting edge stock assessments. Since course participants come from a range of background with difference technical expertise, is difficult to achieve a right balance between introductory concepts and approach and more difficult material. I thought that the course had a good balance in this regard.
- I enjoyed the course and I think it was really useful to address some key concepts. My only suggestion would be for the teachers to slow down a little: they were really helpful, however I think that sometimes they tend to give some concepts for granted.
- Some basic introduction to C++ would be useful. A bit clearer flowchart regarding the exercises as to where and how the C++ part of the code should fit could be of value.

- A lot of grounds was covered in a short week ... So make the course two weeks!
- Very good course! I think would be excellent to have a course only on state space models using TMB.
- It is a very nice course and I really appreciate the effort and dedication of the instructors, they do very well. But it would be even better if the most important and relevant concepts during the course are explained a bit slower, by explaining them in a progressive way, and never forgetting doing a review after, it helps to fix concepts and clear up misconceptions.

• **Annex 4: Graphical summary of responses to course evaluation questionnaire**

**1. \_\_\_\_\_**

**How did you hear about this course?**



Total: 17

**2. \_\_\_\_\_**

**Course content**



Total: 17

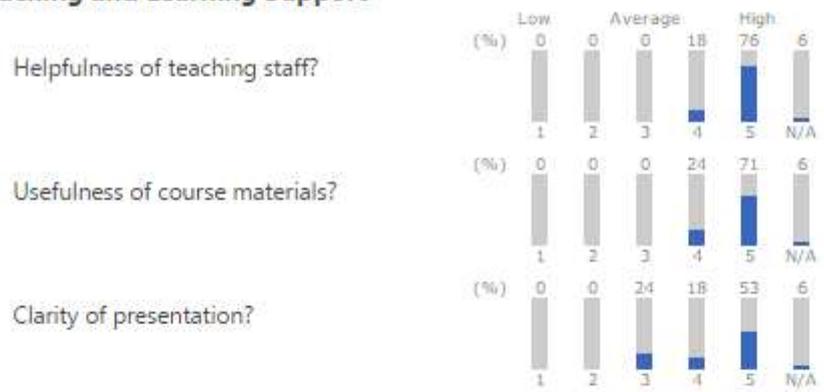
**3. \_\_\_\_\_**

**Course Organization**



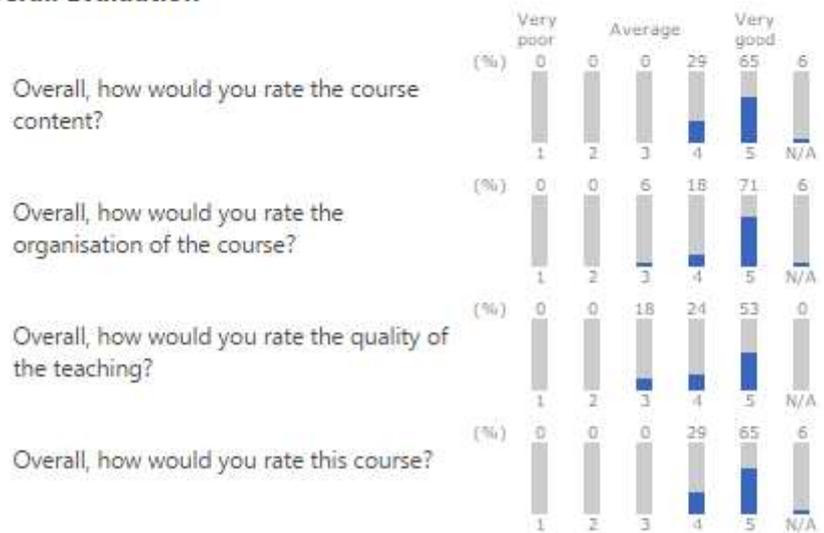
Total: 17

**4. Teaching and Learning Support**



Total: 17

**5. Overall Evaluation**

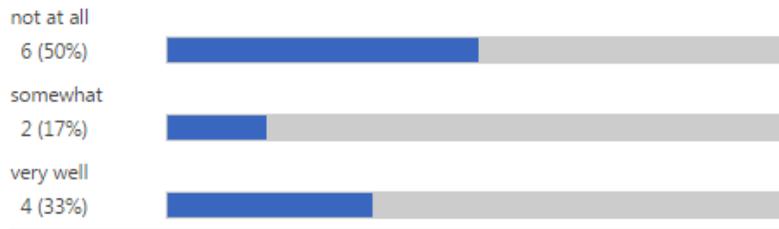


Total: 17

Total: 13

**7. \_\_\_\_\_**

**Have you taken any other ICES training courses? If so, how well did they prepare you for this course?**



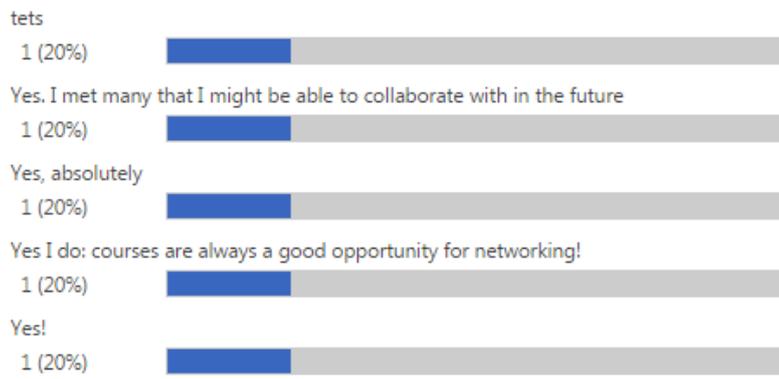
Total: 12

**8. Do you feel you have benefited from networking opportunities on the course?**



Total: 17

**9. Comments**



Total: 5

**10. Did you participate in the course dinner on Thursday evening?**



**11. Would you prefer the course dinner to take place in the city centre, or at the course location (at own expense)?**



**12. More comments**

