Report of the ICES Training Course: Introduction to Bayesian Inference in Fisheries Science (TCBIFS)

7- 11 June 2010

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Contents

Participants at the course "Introduction to Bayesian Inference in Fisheries Science" Training Course 7–11 June 2010 at ICES Headquarters in Copenhagen. The course was given by Samu Mäntyniemi, Fisheries and Environmental Management Group, University of Helsinki, Finland (#7 from left) and Ray Hilborn, School of Aquatic & Fishery Sciences, University of Washington, USA (#8 from left).

Report of the ICES Training Course Introduction to Bayesian Inference in
Fisheries Science, 7-11 June, 2010

by

Ray Hilborn and Samu Mäntyniemi

1   Summary

The training course Introduction to Bayesian Inference in Fisheries Science was
conducted for the first time under the ICES Training Programme 7-11 June 2010 at
ICES Headquarters in Copenhagen. Twenty-six students from 17 countries partici-
pated in the course (Annex 1). From the perspective of the instructors, the course was
a success although some adjustments can improve the knowledge and skill transfer to
the trainees (see 2 Recommendations)

Feedback from students was solicited using a course evaluation questionnaire. Re-
sults indicate that the amount of material covered was "average" to above "average",
degree of difficulty was "average" to "difficult", course organization and the course
description were "average" to "very good," helpfulness of teaching staff, usefulness
of course materials and clarity of presentation were "average" to "high." Overall, the
course content, organisation and quality of teaching were "good" to "very good."
Individual feedback from trainees was:

- "When presenting in the Excel, one has to give time to the students to see
  what is going on. Thus, slower in Excel please".

- "Many institutional budgets are closed by the end of the calendar year. An-
  nouncing training course around November can help potential participants
  to secure their budgets in advance of the course. I really enjoyed this course
  but think that it should be divided in two parts, considering the amount of
  material covered and which could be covered in addition. The balance be-
  tween presentations and practicals (work on WinBugs) is essential and
  should be maintained. The facilities and logistics were perfect".

- "Some initial lecture on likelihood would have been useful".

- "Overall the course was very inspiring and I am leaving with an enthusiasm
  to learn more about the Bayesian method. The teaching staff were enthusias-
  tic and very helpful. However, at the same time, I am disappointed that I
  don't feel I am yet able to completely tie together everything that was taught.
  The start of the course was quite confusing for me and I think this came
  partly from not understanding the different definitions of e.g. probability,
  and a less thorough understanding of likelihoods than was required to fol-
  low. At the end of the week we were given information (e.g. about likeli-
  hoods, distributions) that we would definitely have benefited from at the
  start of the course. So I think the course could be improved by spending the
  first day going over these concepts and definitions (along with the lecture on
  comparing classical and Bayesian approach – perhaps using linear regression
  to contrast the differences as well?) so everyone has the basis needed to build
  on. I think partly this problem arose from the very different background of
  the participants and due to this I think it would be better to have a week for

beginners and a week for intermediate/advanced Bayesian users (or even one specific for stock assessments, versus one focussing on other applications). This way everyone gets more out of it. Another thing I thought were difficult to follow were the demonstrations in excel, as we could not see the cells well on the board and could not keep up with the speed of scrolling through the sheets on our own laptops. So overall I think the course had many positives and is definitely worthwhile course, which I am pleased to have participated on. However, spending some time on the first day really getting to grips with the basics needed would really benefit understanding the rest of the course. I really hope there will be a follow up course as I would definitely like to come back with questions having tried this on my own data".

- "It still would be nice to be able to prepare for the course for a longer period. So instead of having a list of recommended readings 2 weeks before the course starts, it would be nice if there was some references for suggested reading under the course description. It would be a good idea to emphasize that some experience in modelling is required".

- "Considering this was the first time this course was held, I felt the instructors did a very good job. They were prepared to adjust their material once they had a sense of the level of understanding of the students - a challenging job for any instructor. My main suggestion might be to consider 2 levels for this course, a beginner and an advanced level. In terms of material, Samu's style and material was more suited to beginners, while Ray's material was more geared at an advanced/practitioner level".

- "All and all, I got exactly what I was looking for - a good overall sense of what Bayesian statistics can do, and the skills to start on same basic analysis. I will certainly recommend this offering to my colleagues. Well done and thank you to ICES, Soren, Claire, Ray and Samu!"

- "The level of the course was higher than expected. It would have been very helpful to have started with lectures on more basic things, like the lectures that were on Friday".

- "Sam Mäntyniemi did a very good job as a course leader".

- "It would be helpful if the prerequisites of the course were a little better specified so that the material covered is not too difficult for the participants".

- "For the next course I think more time should be spend on introducing the theory and methods during the first days of the course".

- "Try to ensure that all example files are set up correctly and work as intended to".

- "I thought the course was excellent, and learnt a lot. I had a little bit of trouble keeping up with Ray, but I think this may have been due to the fact that I was not familiar with the statistics he was using".

- "This course compares very well with others I have taken. One (minor) criticism I have would be the organisation of materials on the Share point site. This is a very useful resource once the course has been completed and if the

references, presentations and exercise materials were organised better (by using appropriate folder structures and filenames) it would make it easier to navigate the material".

- "Regarding the teaching, once or twice during the course it would have been more helpful for the instructors to work through an exercise in steps with participants completing each step before the solution is outlined rather than asking the participants to complete the exercise in a single step".

- "Set out with the goal of getting a good understanding of the basic concepts behind Bayesian Inference and this goal was well achieved".

- "I think the days are probably a little long, especially with such an intensive program".

- "For me personally, there was too much material and therefore the pace meant that some of the ideas were not thoroughly understood. However this is understandable with such a variety of students with varying backgrounds. Might have been helpful to have step by step guides outlining procedures for people to refer to when working on tasks and take away for self-study".

- "I felt this course was very well delivered, and whilst some parts of the week I found very difficult, the quality of the lecturing was outstanding. I would recommend this course to anyone interested in Bayesian inference".

2   Recommendations

The major issue we identified was a discrepancy between the participants understanding of probability theory and maximum likelihood estimation, and the instructors expectations. We began the course at a higher level than most students were prepared to understand, and had to go back later in the course and review some material the instructors had assumed would be understood. If we had stringent entry requirements in terms of understanding of this material it seems unlikely we would have had enough participants to offer the course. As we felt that most participants profited from the course, the best approach seems to be a combination of providing more background reading and material, and reviewing probability and likelihood in the first day of the course. Therefore we recommend:

- Prior to the course provide students with background material on probability and likelihood.

- Prior to the course provide some sample "exercises" that students should complete.

- More time is needed in the beginning to explain the basic concepts of Bayesian and classical statistics. We assumed more knowledge about the likelihood based inference than was present among majority of participants. The likelihood lecture given on Thursday as a reminder should be given on the first day.

- A very detailed and slow construction of prior, likelihood and posterior should probably be done by everyone in the beginning, using Excel or their favourite program. Maybe with two exercises: one with binary variable and one with a continuous variable.

- Introducing two simulation based integration methods within five days may have been a bit two much. Since most of the practical work is nowadays done using MCMC, we might prefer concentrating more on that. This could potentially free up some more time for the student problems or more specialised lectures.

- Logistic growth model is good to have in the course program. However, it would probably be best to have it in the end of the course.

- Ray´s real life examples about meta-analyses and stock assessments around the world really put the course into its context. We should make sure to have enough time for those examples.

- Splitting the group on the final day seemed to be an efficient way of working. This method could perhaps be used more often.

- At least Samu was carried away by the final session on student problems, so that he lost the track of time. It would be good to have a closing summary session and session for questions and answers in the end. We planned to have them, but it did not really happen.

3   Course description

Management advice provided by ICES has its roots in the work of stock assessment working groups comprising of experts on the stocks to be assessed. In addition to their expertise on the stock of concern and the population models of the stock, another important part of the expertise is the knowledge about the population dynamic parameters and their relationships derived from other stocks and the historical experience in fisheries. Traditional stock assessment methods can only use the data available for the stock of interest, which means that all other knowledge has to be left out from the quantitative analysis. The Bayesian approach to scientific reasoning provides a mechanism to incorporate this other knowledge and experience. The Bayesian approach is a mathematical logic for quantifying and processing expert knowledge, which enables direct integration of the prior information possessed by experts and their interpretation of the observed data.

Bayesian methods also provide a mechanism for the quantification and computation of uncertainty that is directly applicable to decision making. Traditional statistical methods only describe the sampling process while assuming known state of nature; (stock size for instance) there is no measure of uncertainty about the state of nature itself. Thus, the scientists are not able to make probabilistic statements of uncertainty about the status of the stock or the population dynamic parameters. Bayesian analysis results in clear probability statements such as "there is a 90% probability the stock is between 1200 and 3000 tons", and these probabilities can then be directly used in decision analysis to inform the management advice.

The objective of this course is to familiarize the participants with the basic concepts of Bayesian inference and to provide skills for solving simple problems. The participants will have hands on experience about using MS Excel and OpenBUGS software for Bayesian computation. The topics to be covered include:

- Principles of the Bayesian reasoning

- Differences and similarities between the Bayesian approach and conventional statistics

- Numerical integration methods: Markov chain Monte Carlo (MCMC) and Sampling importance resampling (SIR)

- Bayesian regression analysis (or estimation of a mean)

- Bayesian Mark-Recapture analysis

4   Course programme and instructors

The programme was circulated to all participants prior to the course, and is available for download from the ICES Share Point Site.

The programme was designed with an about even split between lectures/discussions and tutorials. In summary form the programme was (details in Annex 2):

Day		Topic
Monday	AM	Modes of inference: compare Bayesian concepts to p-values, likelihood profiles and confidence intervals
	PM	Logistic growth model:
		- Excel direct search
		- SIR and convergence criteria
Tuesday	AM	Introduction to MCMC:
		- Estimation of a mean
		- Convergence criteria
	PM	OpenBUGS: mean and linear regression
Wednesday	AM	Mark - Recapture using Open-BUGS
	PM	Mark - Recapture problem in Excel
Thursday	AM	Hierarchical stock recruitment model
	PM	Hierarchical stock recruitment model
Friday	AM	Student problems
	PM	Student problems Summary

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Annex 1: List of participants

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Annex 2: Detailed course programme

The detailed course programme is presented below. This is the version showing the actual course progress, and it is modified from the official (pre-course) programme as the course progressed. Participants were kept up to date about the program through the course share point site.

PROGRAMME:

Time	Event	
Monday, 7 June 2010		
9.00 – 10.00	Welcome ICES Staff -About this course (Samu and Ray) Introduction of participants and lecturers; expectations	
10.00 – 10.30	**Tea/Coffee**	
10.30 – 11:30	Lecture Samu: Introduction to Bayesian inference and comparison to classical statistics	
11:30-13:00	Lecture Ray: Introduction to decision analysis	
13:00-14:00	**Lunch**	
14.00 – 15.30	Lab Ray: simple integration of standard statistical problem - linear regression in Excel	
15.30 – 16.00	**Tea/Coffee**	
16.00 – 18.00	Continuation of afternoon lab	
18.00 – 20.00	*Icebreaker*	
Tuesday, 8 June 2010		
9. 00 – 10.15	Lab Ray Logistic growth modelling with SIR in Excel	

10.15 – 10.45	**Tea/Coffee**	
10.45 – 13.00	Lecture Samu Introduction to MCMC and WinBugs and convergence issues	
13.00 – 14.00	**Lunch**	
14.00 – 15.30	Lab Samu: simple mark recapture model using MCMC	
15.30 – 16.00	**Tea/Coffee**	
16.00 – 18.00	Continuation of mark recapture lab	
Wednesday, 9 June 2010		
9.00 – 10.15	Lecture Samu: more advanced WinBUGS	
10.15– 10.45	**Tea/Coffee**	
10.45 – 12.00	Lab Samu: linear regression with WinBUGS	
12:00-13:00	Continuation of linear regression lab	
13.00 – 14.00	**Lunch**	
14.00 – 15.00	Lecture Samu: combining process and observation models: shrinkage	
15.00 – 15.30	**Tea/Coffee**	
15.30 – 18.00	Lab Samu: Joint analysis of mark-recapture data and stock recruitment model	
Thursday, 10 June 2010		
9.00 – 10.15	Lecture Ray: hierarchic stock recruitment models	
10.15 – 10.45	**Tea/Coffee**	
10.45 – 13.00	Continuation of hierarchic modelling in lab	

13.00 – 14.00	**Lunch** & Group photo	
14.00 – 15.00	Continuation of hierarchic modelling in lab	
15.00 – 15.30	**Tea/Coffee**	
15.30 – 18.00	Continuation of hierarchic modelling in lab	
18.15 – 22.00	Course dinner (optional, expenses to be covered by participants)	
Friday, 11 June 2010		
9.00 – 10.15	Reserved for lecture material left incomplete earlier in week	
10.15 – 10.45	**Tea/Coffee**	
10.45 – 13.00	Student problems: each student will do a Bayesian analysis of a data set they know well	
13.00 – 14.00	**Lunch**	
14.00 – 15.00	Question and answer session; discussion; evaluation (written)	
15.00 – 15.30	**Tea/Coffee**	
15.30 – 16.00	Closing	