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Report of the Workshop on the use of FLR for fish stock assessments (WKFLR)

29 January - 2 February 2007

ICES Headquarters, Denmark

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Conseil International pour l'Exploration de la Mer

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Executive summary

This was the first course in fish stock assessment techniques using Fisheries Library in R (FLR). The course consisted of a number of practical exercises on data, combined with some lectures, presented as power point slides. Participants were invited to bring catch at age data and tuning series data used in stock assessment working groups, to adapt the example exercises so that they could be used for future assessments. There were 27 participants, a substantial number of whom did indeed bring their own data.

The aim of the course was to show the use of R in combination with FLR in assessment working groups. The topics covered included Exploratory Data Analysis (EDA), analytical stock assessment methods such as XSA and ICA, analysis of assessment results, Short Term Forecasts, estimation of Stock Recruitment Relations and Biological Reference Points, and finally Management Strategy Evaluation.

The backbone of the practical analysis material was a set of web pages, which are also available outside of the course. These web pages are grouped according to the different topics, and consist of example R code and explanation on the functionality of FLR. This material was presented in a way to cover the R and FLR basics first, followed by the more complex methods, such as the assessments and forecasts.

While the course was intended for experienced assessment analysts with experience in R, most of the participants lacked knowledge of R. Although the course did start with a short explanation of the R syntax and structure, the lack of R knowledge slowed down progress of the participants. On the other side, the course made use of the latest version of FLR, which unfortunately contained some minor bugs in the plotting routines, which were fixed during the course.

From a round-the-table discussion at the last day of the course, most participants seemed to have gained much experience from the course. However, there was some concern about the question if the participants would now be able to operate fully independently in an assessment group context. One of the ideas that came up during the course was to set up tools for sharing the scripts used for the different stock assessments. This should then be coordinated by ICES.

1 Workshop summary

1.1 Terms of Reference

a) teach a course on the use of the Fisheries Library in R (FLR) in stock assessment working groups covering evaluation of data consistency, estimation of the state of a stock, projection of stock status, uncertainty evaluation and risk assessment.

Supporting Information

PRIORITY:	In order to maintain and improve the quality of ICES advice, continual education in new and modern modelling tools that take into account new scientific ideas is necessary. The training undertaken in this Workshop is essential for ICES to assure the quality of the ICES advisory function and of its fish stock assessments in the longer term.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan Numbers 4.10 and 6.7.3. A series of courses in fish stock assessment was started in 2002 as WKCFAT, with teaching principles and practice of XSA and ICA, followed by the WKAFAT with a somewhat broader scope, which was conducted in 2004, 2005 and 2006, but is not planned for 2007. Plans for teaching within ICES are under development and it is becoming increasingly evident that a range of courses at different levels is necessary to fully cover the needs for expertise in the ICES community, including courses on special topics like this one. FLR is a framework for simulating and analyzing data and management regimes with a variety of methods. It has been developed over several years, and is increasingly being used by assessment working groups. There is a strong need to further distribute the insight in using this tool, in particular to the assessment working group environment. The workshop on the use of FLR in stock assessment intends to concentrate on how FLR can be made operational in a stock assessment working group, focusing on the tools for exploratory data analysis, stock assessments, and stock forecasting within the framework. The course will be a given as a combination of lectures and practical exercises using FLR. The course will be developed on a series of WiKi webpages that will remain available after the course has been completed. . The course will require some previous insight in fish stock assessment, e.g. through experience from assessment working groups, and intends to give the participants a broader and deeper insight in the field. Some experience with R is also necessary. The course is not intended as a first introduction to neither R nor to analytical assessment.

1.2 Background

This was the first course in fish stock assessment techniques using FLR. Previously, courses had been given concentrating on the standard software tools for stock assessment used in ICES, as well as a course on advanced stock assessment techniques. The course takes the recent developments of FLR as a tool in assessment working groups into account, emphasizing the importance of understanding and scrutinising the input data, the ability to use a broad range of analytical stock assessment models, and to cover the simulation methods for Management Strategy Evaluation. Although the course has a different set of objectives compared to the earlier WKAFAT course which was held from 2004 to 2006, some elements were preserved, such as a focus on data exploration and evaluation, and the demonstration of

non-linear optimizers to develop stock assessments. Also, like WKAFAT, the course was aimed at experienced analysts with experience in stock assessments.

1.3 The workshop

The course consisted of a number of practical exercises on data, combined with some lectures, presented as power point slides. Participants were invited to bring catch at age data and tuning series data used in stock assessment working groups, to adapt the example exercises so that they could be used for future assessments There were 27 participants, a substantial part of which did indeed bring their own data.

The aim of the course was to show the use of R in combination with FLR in assessment working groups. The topics covered included Exploratory Data Analysis (EDA), analytical stock assessment methods such as XSA and ICA, analysis of assessment results, Short Term Forecasts, estimation of Stock Recruitment Relations and Biological Reference Points, and finally Management Strategy Evaluation.

The backbone of the practical analysis material was a set of web pages, which are also available outside of the course. These web pages are grouped according to the different topics, and consist of example R code and explanation on the functionality of FLR. This material was presented in a way to cover the R and FLR basics first, followed by the more complex methods, such as the assessments and forecasts.

It was the intent of the instructors to show the possibilities of R and FLR with respect to:

- Reading in standard data formats used for storing data on the stock and the tuning index series.
- Exploration of the input data using default plots for the different data types in FLR, user defined multi-panel plots, and some of the built in functions for log catch ratios and catch curves.
- Different analytical stock assessment and forecasting tools
- Numerical simulations of fisheries systems for Management Strategy Evaluations

The FLR packages consist of a core (FLCore) which contains the standard classes for fisheries simulation, and the secondary packages, which contain methods for EDA, analytical stock assessments, forecast, estimation of Stock Recruitment relations and Biological Reference Points. These packages combined with the standard functionality in R for estimation and plotting were the backbone of the practical training in the course.

Several sets of input data were provided to the group for the analysis throughout the course. These data were real-life estimates of stock properties in ICES areas, such as plaice in the North Sea and Southern Hake. Also, participants brought data to analyze, so that there was also analysis of e.g. herring in the central Baltic and cod in the Kattegat and the Western Baltic. The analysis for each of these stocks was adapted to its specific needs.

The time schedule and the items covered are shown in the time table below.

Monday (10:00 - 17:00)

- Brief introduction to R, including an installation tutorial and practical introduction to R
- Introductory presentation to FLR (Fisheries Library in R)
    - philosophy
    - S4 classes
- The FLQuant, including a practical tutorial with exercises on creating FLQuants, subsetting and using methods: window, summary, plot.

- FLCore composite classes and the accompanying methods, including a practical composite object tutorial on creating FLStock and FLIndex objects for other stocks from VPA files brought by participants. The classes include
    - FLStock represents a stock object and contains the information required for conducting an assessment
    - FLBiol represents the underlying biological population that comprises part of the Operating Model
    - FLFleet represents a fleet object which may be the entire fishery or just a single vessel
    - FLCatch a component of FLFleet representing the catches of a specific stock, species or population
    - FLIndex represents a index of population abundance for use in stock assessment

Tuesday (9:00 - 17:00)

- Introduction to FLEDA, a secondary package for Exploratory Data Analysis, using a FLEDA tutorial on a plaice in the North Sea dataset. The tutorial included exercises to use FLEDA to make plots of yield trends, yield vs. effort, catch at age, time-series of tuning indices, internal consistency of tuning indices, catch weight, biomass trends, catch curves estimation of total mortality.
- Conducting analytical assessments in FLR, using a tutorial on the FLXSA secondary package. This tutorial includes exploring and selecting data, performing the XSA, and inspecting and printing the results of the assessment.
- Analysis of stock and recruitment relationships using assessment outputs, using a tutorial on the SR class in FLCore. This class includes methods for estimating parameters for different stock and recruitment relationships, such as Beverton and Holt, Ricker, and segmented regression. These can be estimated using non-linear optimizers, or Bayesian statistics. Plots are available for the evaluation of the results.
- Tutorial on Short Term Forecast using the secondary FLSTF package. This tutorial includes changing the different assumptions made in the forecast, such as the level of recruitment, the time window of averaging weights used in the prediction, or setting estimates in the intermediate year derived from other sources.

Wednesday (9:00 - 17:00)

- Creating custom statistical catch at age stock assessments using the R optimizer, including some basic methods for generating stock and catch data with known properties.
- Using Survey Based Assessment methods, in the secondary FLSurba package.
- Using FLICA, a secondary package for performing the ICA stock assessment method.

Thursday (9:00 - 17:00)

- Using FLR for numerical simulation of fisheries for Management Strategy Evaluation. This is an essential part of the course, because the FLR framework is a development effort directed towards the evaluation of fisheries management strategies. In particular, the framework enables to implement and link a variety of fishery, biological and economic software so that alternative management strategies and procedures can be evaluated for their robustness to uncertainty before implementation. The two main questions to be addressed are
    - Does the stock assessment procedure provide estimates with reasonable accuracy and precision given the fishery system.
    - is a management strategy capable of achieving the management goals.

The MSE approach requires mathematical representations of two systems: a 'true' system and an 'observed' one. The 'true' system is represented by the operating model (OM) that simulates the real world. In contrast, the 'observed' system represents the conventional management procedure (MP), from the data collection through stock assessment to the management implementation. A relatively simple example was presented which used the results of the working group stock assessment as the basis for the Operating Model and makes assumptions about the selection pattern of the fishing fleet and its dynamics. The model comprises a single stock that is fished by a single fleet. It implements a relatively simple harvest control rule through a management procedure that explicitly models the stock assessment process and time lag in implementing the management advice.

- Developing Packages in R. FLR is an open source software development initiative. Whilst the core package, FLCore, is developed and maintained by the FLCore development team, contributory packages may be developed by anyone. A practical introduction to the package development procedure. In order to stimulate the development of more secondary packages by the participants of the course a tutorial on the package development was presented.

Friday (9:00 - 15:00)

This last day was used for participants to spend more time on the subject of their choice. Also a plenary discussion was organized on the evaluation of the course material, and the future direction of FLR with respect to the ICES stock assessment work.

2 Experiences

There was considerable interest for the course, and with 27 participants, the maximum set number of 25 participants was slightly exceeded. The participants had very broad range of experience in R and assessment work. In all, the course may thus have been ambitious for most students, while at the same time too elementary for some. The presentation was adjusted to some extent to spend more time on elementary theory of Object Oriented Programming, which is the foundation of R and FLR, However, rapid progress in R skills was unavoidable given the field that was expected to be covered. Although the participants concluded that a fair compromise was reached, most also felt they were not able to do the standard assessment work by themselves for those stocks not covered during the course. Within the present course framework the following points were raised in the final plenary in regards to improvement of the course:

- A more in-depth introduction to R syntax and OOP.
- More information on how to explore the contents of an R workspace and the attributes of individual objects
- A short morning session, giving some background on the practical tutorials.
- A tutorial on reading in data from other sources than the VPA suite files, and coercing objects of standard R classes to FLQuants

3 Interaction between FLR and ICES, including future teaching of FLR

FLR has proven to have the potential to increase the efficiency and accuracy of stock assessment working groups, by putting the data exploration, analytical assessment and forecasting in a single statistical environment (R). The R environment makes use of scripts that can be stored and re-used and shared. As such, FLR has already been used to in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak for sole and plaice in the North Sea. Also, both WGNSDS and WGHMM will extensively use FLR to do this years stock assessments.

However, FLR is a tool that is under constant development, and efforts to add or check functionality are generally made under EU-projects, that do not have performing ICES stock assessment as a primary goal. In order to aid the stock assessment working groups to increase the use of FLR, while ensuring correct results, it was suggested by the participants of the course to develop a framework in which FL(R) can be stored and publicly viewed, in order to share knowledge among stock assessment working group participants.

It was also reiterated that ICES could provide a platform for testing the results of secondary packages used in the stock assessment working groups to known results for a large number of stocks and scenarios. Such tests have been suggested and described by the Working Group on Methods of Fish Stock Assessments in 2004. Such a platform would ensure accurate results from the packages, while these are further developed. At present, this testing is the responsibility of the individual developer of the method, and although progress has been made on this subject, the mechanisms in place have shown not to be very robust.

ICES is heavily dependent on the assessment skills of Working Group participants, and both the conveners and the participants felt strongly that ICES needs to further develop a strategy to ensure the competence by those who do the assessment work in the tools that were presented.

Except for the methods that were presented at this course, which focuses on the “classical” analytical stock assessments done in assessment working groups, ICES might consider to also teach management strategy evaluation in FLR. This is specifically what FLR is aimed for, and during the one day of teaching, only the very basics could be taught, without going into much detail. Such a course, which deals with assessment methodology within the context of management under uncertainty and evaluation of management strategies was also envisaged and recommended by WKAFAT in 2006. As it was formulated then it should cover methods for the design and testing of management procedures, taking into account uncertainty in the process, measurement error, estimation, model and implementation error.

4 Acknowledgements

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Annex 1: List of participants

Met 29 January – 2 February 2007, ICES Headquarters, Copenhagen, Denmark

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