"FEMS"

A framework for evaluating management strategies in fisheries

The management of fisheries increasingly embodies multiple and conflicting biological, ecological, economic and social objectives. However, despite constant efforts to regulate fisheries by regional management bodies and national governments, fishing capacity often remains above that necessary to ensure the sustainable exploitation of marine resources, especially in developed countries. This failure has been analysed in depth during the past decade by the scientific community, which has repeatedly recommended substantial changes in incentives and governance, as well as adjustments in the way that fisheries research and monitoring are conducted and expertise is deployed.

The **FEMS** project proposed to **develop a computer-based simulation framework that allows evaluating the performance of management strategies that are consistent with the precautionary approach whilst maintaining the viability of the fishing industry**. A simulation framework was chosen since it is difficult or undesirable to compare alternative strategies by conducting experiments on real fisheries.

Initially simulation models (referred to as base cases) were developed for the study of stocks (demersal and large pelagics) consistent with current dynamics assumptions and management procedures as used by the International Council for the Exploration of the Sea (ICES) and the International Commission for the Conservation of Atlantic Tuna (ICCAT). The following base cases were selected:

- North Sea Demersal (ICES):
  - ◊ Cod
  - ◊ Plaice
  - ◊ Flatfish (plaice and sole)
- North Atlantic & Mediterranean Tuna (ICCAT)
  - ◊ Albacore
  - ◊ Bluefin
  - ◊ Tropical (bigeye, skipjack and yellowfin)

These cases were chosen because of their importance but also to help develop a general framework that could cope with a variety of biological, sampling, fleet and assessment types.

Evaluation was performed by comparing the trade-offs between management objectives, e.g. sustainability of the stock, level of yield(s) and variability in yield. This permitted the performance of data collection schemes, assessment methods and management regulations (e.g. harvest control rules and/or recovery plans) to be evaluated against plausible hypotheses about fishery dynamics.

A major failing of conventional management advice has been that it does not explicitly incorporate important sources of uncertainty. For example, it is generally assumed that (i) input data are appropriate and not biased, (ii) stock assessment models accurately reflect both population and fisheries dynamics, and (iii) management measures are perfectly implemented.

The FEMS framework, however, has explicitly taken into account uncertainty, which makes it possible to evaluate the relative importance of the various

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Coordinator
Dr. João Gil Pereira
Universidade dos Açores
Department of Oceanography and Fisheries
Campus da Horta, Cais de Santa Cruz
9901-862 Horta (Açores)
Portugal

Phone: +351-292-200-431
Fax: +351-292-200-411
Email: pereira@notes.horta.uac.pt

"FEMS PROPOSED AND INITIALLY DEVELOPED A GENERIC FRAMEWORK THAT HAS NOW BECOME KNOWN AS THE CORE OF THE FLR (FISHERIES LIBRARY IN R) INITIATIVE"

elements of the scientific advisory system, such as

- Data quality
- Assessment methods
- Understanding of the biology
- Response of the fishers to regulations
- Interactions between these (e.g. discarding)

The FEMS framework has now become known as the FLR initiative (www.flr-project.org). From a general perspective, FLR aims to provide a solid basis for the development and evaluation of methods in fisheries science. It allows operating models to be developed, conditioned on a variety of data and hypotheses, and alternative stock assessment and management procedures to be implemented in software.

FLR can also be used to perform exploratory data analysis and provide estimates of population parameters based upon a range of data and assumptions in order to create and run simulation operating models. It can also perform stock assessments (incorporating existing methods written in Fortran and C/C++ and any new methods that are developed) and test harvest control rules for stock assessment working groups. All of this can be done in either a frequentist or Bayesian framework. In addition FLR is currently being extended to incorporate mixed fisheries, multispecies and ecosystem and economic models. Routine for automatic differentiation are also being included to help increase the running speed.

FLR is constantly being further developed and is supported by various projects including the EU-funded projects COMMIT (FF-ALL-ADVICE-04), EFIMAS (FF-ALL-ADVICE-01), FISBOAT (FF-ALL-STOCK-01) and UNCOVER (FF-ALL-RECOV-01).