NASCO

Agenda item 4.2
For decision

Council

CNL(03)9

Report of the SALMODEL Project

The SALMODEL Project is a major EU-funded project that has just been completed. The scientists involved in the project are very keen that the results are clearly conveyed to managers. The main aim of the project was to develop methods for establishing conservation limits and pre-fishery abundance estimates for the North-East Atlantic Commission area. The findings are, however, also of relevance to management of the West Greenland fishery. A brief report on the project is attached. Some of the project's findings have already been incorporated into the ICES advisory process for Atlantic salmon.

The Coordinator of the project has proposed that a Special Session be held at NASCO's Annual Meeting in 2004 to allow more detailed presentations of the project's findings. The Council is asked to consider this proposal.

Secretary
Edinburgh
7 April, 2003

A coordinated approach towards the development of a scientific basis for management of wild Atlantic salmon in the North-East Atlantic
(SALMODEL)

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Background to the SALMODEL Concerted Action

In 1999, a group of national representatives to the ICES Working Group on North Atlantic Salmon (WGNAS), together with others, agreed that for salmon stocks in the NEAC area further development of Conservation Limits (CLs) and Pre-Fishery Abundance (PFA), as required for providing catch advice for distant water fisheries, could best be achieved through an internationally co-ordinated project. Such co-operation is essential, as most of the work to develop assessment and modelling techniques depends on grouping of national and other data sets. It was also envisaged that many of the aspects of CLs and PFA that would be investigated would also be highly relevant to regional and local fishery management as well.

Accordingly, SALMODEL was initiated and was set up as a European Commission funded Concerted Action, in 2000, for a three-year period, with the overall aim to:

"Advance the scientific basis upon which advice is given to managers of local, national and international salmon fisheries, compatible with the Precautionary Approach, as adopted by NASCO and within the requirement of sustainability (the core concept of Key Action V of the EU Fifth Framework)".

Against this requirement, specific objectives were:

- *To improve our ability to set salmon conservation limits (CLs); addressing transportability and dynamic change issues, also taking into account underlying stock structure, and;*
- *To examine methods of estimating pre-fishery abundance (PFA) for North-East Atlantic Commission (NEAC) salmon stocks and to determine whether and how PFA estimates can be used to give catch advice.*

The scale and complexity of managing north-east Atlantic salmon stocks is put in context when one considers the limited number of stocks for which detailed information is available relative to the approximately 1,500 salmon rivers represented by the north-east Atlantic countries from Spain to Russia. This dictates that, for most stocks, management must be based on parameters inferred from other stocks.

A further limiting factor is that the available information is not distributed evenly amongst the stocks, potentially limiting the scope for meaningful inferences among stocks. For example, of the 23 European stocks where stock and recruitment information (SR) exists, 16 occur in the southern European group of countries comprising France, Ireland and the UK, while only seven are available for the northern European group of countries (Finland, Iceland, Norway and Sweden).

This document summarises the work carried out by SALMODEL, including key achievements, implementation of the results and current and planned dissemination activities. A full account of the work will be available in the final report, which will be released as a stand-alone fully referenced scientific report, following approval by the European Commission.

Key achievements of the SALMODEL Concerted Action

Conservation limits

- SALMODEL carried out a review of the Precautionary Approach and Atlantic salmon management, including identification and choice of biological reference points (BRPs); management strategies that are (or might be) used, together with the first ever country-by-country survey of salmon management objectives operating around the NEAC area;
- The state of progress with setting of conservation limits (CLs) for Atlantic salmon in the NEAC area at the time the project started was reviewed, with methodologies being used, practical issues arising in the use of these and prospects for future progress assessed. As part of this, a comprehensive review of data quality and quantity available to NEAC countries was carried out, with particular emphasis on stock and recruitment (SR) data sets. Data availability was compared with that in North America and also between northern and southern NEAC stock groupings;
- Fifteen of the NEAC SR data sets were subsequently used in a new approach to developing CLs, by applying Bayesian hierarchical stock-recruitment analyses (BHSRA) to derive probability distributions of reference points for rivers with no SR data based on the joint treatment of rivers that do have these data. This method makes

best use of the existing SR data series, and accommodates several important sources of uncertainty in CL setting;

- The BHSRA approach has produced a framework for setting CLs at regional and national levels, contingent on developing data on wetted area to use as a scaling factor between rivers. A review conducted within SALMODEL indicated that Geographic Information System (GIS)-supported technology is evolving very quickly and offers the ability to achieve this very quickly and cost-effectively. This is expected to replace the existing 'pseudo' SR methods for setting national NEAC CLs at ICES, which was, however, significantly improved by SALMODEL as an interim measure.

Apart from the core tasks of setting and transporting conservation limits, SALMODEL also investigated a number of important issues associated with use of conservation limits, many of which had not previously been addressed for NEAC or other Atlantic salmon stocks:

- SALMODEL addressed, in detail, non-stationarity in the recruitment process for stocks in the NEAC area, examining all available SR data sets for factors causing temporal variation in productivity parameters, and analysing in depth two data sets to understand implications of non-stationarity processes for CL setting;
- Review work undertaken in SALMODEL addressed for the first time the potential impact of migratory trout in CL setting for Atlantic salmon. Two approaches were adopted, with analysis of sympatric occurrence in several countries and literature survey to draw inferences on studies on trout:salmon competitive relationships;
- A novel modelling approach was developed to test combining goals of optimal harvesting with maintaining effective population size in a group of populations interconnected by migration. This effectively tests potential genetic consequences of use of CLs that may not take account of population structure. A number of rules for considering levels at which CLs are set and harvest strategies employed were derived from this modelling and this was further tested in a unique application using real data from salmon rivers;
- The use of reference points in fisheries management requires that the probability of achieving the objectives is taken into account. Using theoretical and actual stock data, SALMODEL modelled the effects of harvesting mixed stock aggregations on probability of achievement of management objectives for the contributing populations, considering the effects of various stock characteristics such as sex ratio, relative productivity, migration rates and stock size.

Pre-fishery abundance

The NEAC run-reconstruction model currently used for estimating national PFA at ICES was fully reviewed and significant actions were taken to improve national data sets:

- The performance of the model was fully assessed, particularly in respect of sensitivity to input parameters, including impact of unreported catches and escaped farmed salmon on PFA estimates. These changes were implemented at ICES;
- Given the importance of estimates of natural marine mortality (m) in run-reconstruction models, SALMODEL gave special attention to verifying methods for estimating m. Accordingly, marine survival trends in European and North American

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stocks, together with factors influencing marine survival, were examined at a special SALMODEL workshop held in Canada;

- Various methodologies including inverse weight and maturity schedule methods were applied to recent data on salmon from European and North American populations to calculate mortality during the second year at sea. These indicated that the currently used value of 1% per month was most likely an underestimate and that a revised value of around 3% per month was more appropriate. This evidence was presented to ICES and implemented at the 2002 meeting of the WGNAS;

- Recognising that the existing run-reconstruction methods for estimating PFA of NEAC stocks are historically based and cannot be used directly for quantitative catch advice, SALMODEL investigated the potential for developing for the first time a forecast of PFA for these stocks;

- Extensive work was carried out into obtaining data on sea surface temperature and investigating various ways in which the data could be used, ranging from averages, percentiles, and rates of change of temperature. These and other marine environmental indices were examined in relation to survival and abundance data for NEAC salmon stocks. These data extractions were made available to all SALMODEL members and to ICES for investigative work at various scales, ranging from single river through regional/national to northern and southern stock complexes;

- Several of the investigative studies provided a tentative basis for developing forecasts of PFA. However, in many cases the number of significant relationships was similar to the number that might have been expected by chance and it has been difficult to determine which may have genuine biological significance. Turning these relationships into predictive PFA models also proved challenging, as in many cases the stock variables that might be useful as inputs, such as lagged spawners, proved to be uninformative. Where juvenile stock variables were tested these proved informative at single stock level;

- In addressing the development of a model or models to predict PFA for NEAC salmon stocks at West Greenland and at Faroes, SALMODEL applied a variety of model formulations to data on stock and historical PFA for relevant stock groups, together with appropriate marine habitat data. A model similar to that employed to predict PFA of North American two-sea-winter (2SW) salmon was applied to southern NEAC salmon (including the same habitat index), but modified to reflect any attenuation of spawners at different levels of spawning. This provided a forecast of southern European multi-sea-winter (MSW) salmon; however, the outcome was driven overwhelmingly by the downwards linear trend in log*(PFA/Eggs)*, which appeared highly time-dependent. This was subsequently presented at ICES and used in the 2002 Working Group report;

- SALMODEL concluded that the lagged spawner variable was a relatively uninformative stock variable in PFA modelling in the NEAC area and recommended that alternative stock variables should be sought. Accordingly, the potential to develop juvenile indices or estimates for the NEAC stock complexes was investigated for the first time. SALMODEL concluded that this could not be achieved at present, but recommended that countries should consider supplementing existing data sets on smolt production, using other data on juvenile abundance at parr stages;

- An alternative approach to addressing PFA prediction was investigated, based on application of Bayesian statistical techniques applied to various model formulations combining biological and environmental data. This approach provided a highly

satisfactory model, which gave a probability distribution of forecast PFA at single stock level and which responded to changes in marine survival. It is recommended that this approach could be developed for larger groups of stocks;

- SALMODEL also considered how salmon stocks may be grouped for the provision of management advice, examining evidence on how stocks can be grouped using genetic data, life-history ecological traits, growth and survival trends and fisheries data including catches and exploitation rates. A number of simple rules for grouping stocks were developed, based on requirements for describing status of stocks, estimating PFA or when developing management advice for distant water fisheries.

Dissemination activities

The dissemination of the results from the SALMODEL project has been highly successful, as SALMODEL pursued a strategy of feeding developments through to external customers as the project progressed, rather than waiting until the end. This took place mainly though the ICES WGNAS and the ICES Annual Science Conference, with a total of 14 SALMODEL papers being presented at ICES meetings or working groups. In addition:

- The proceedings of the workshop on marine mortality (15 papers) are currently in press and will deliver a major contribution to the important debate on salmon survival at sea and how changes in survival are addressed in PFA modelling. Publication of this by DFO Canada will ensure that it reaches a wide audience in the Pacific as well as Atlantic spheres;
- Five scientific papers produced during the project targeted a range of refereed journals and popular scientific literature. Others are currently in preparation;
- A searchable CD ROM containing all 76 working papers presented at SALMODEL meetings, together with annual progress reports and all external outputs, has been produced and is available on request to the co-ordinator;
- A SALMODEL website (www.salmodel.net) has ensured that the maximum audience has been reached and kept updated on progress during the project.

Future plans

Dissemination is expected to continue after the SALMODEL contract period, with plans in hand for further scientific outputs and also dissemination targeted specifically at managers:

- SALMODEL will publish the final report on the website once it has been approved by the European Commission for external release, together with any outputs produced up to one year after the project finishes. This will extend the value of the website well beyond the end of the project and will help ensure maximum dissemination of the findings;
- SALMODEL will present a number of papers at the special theme session on managing mixed stock fisheries at the ICES Annual Science Conference in Estonia in September 2003. A SALMODEL scientific symposium is also being considered, but this will be subject to obtaining funding;
- The submission of papers in refereed journals of high standing, together with other popular scientific literature, will continue. Further papers are already under preparation;

- **SALMODEL has concluded that dissemination to managers would be best achieved through NASCO, and wishes to explore the possibility of having a Special Session at the NASCO Annual Meeting in 2004. The idea would be to present the results of the project, specifically tailored for the management audience (not just a re-presentation of the existing scientific outputs), in order to inform and to trigger discussion and feedback. Feedback is vital, as some of the key areas SALMODEL addressed will be continued after the end of the project, so it will be important to have opinions from managers about where they see the greatest benefits arising.**

Conclusions

SALMODEL set out to address a very challenging set of objectives in relation to the scientific basis for management of wild Atlantic salmon in the north-east Atlantic area, by co-operation and sharing of data and ideas among the NEAC countries. This has been demonstrably the case and the implementation of key advances made in SALMODEL will significantly enhance the scientific basis of management of NEAC Atlantic salmon stocks.

For further information contact the co-ordinator, Walter Crozier (walter.crozier@dardni.gov.uk) or visit the SALMODEL website (www.SALMODEL.net).