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**REPORT OF THE WORKING GROUP ON RECRUITMENT
PROCESSES, WORKING BY CORRESPONDENCE
DURING 1992/93**

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I. TERMS OF REFERENCE

The last meeting of the Recruitment Processes Working Group (RPWG) was held in Fuengirola (Spain) in June 1992. At that time the group made a number of recommendations, which were all subsequently endorsed at the ICES Statutory Meeting (1992) in Rostock. The RPWG was authorised to work by correspondence during 1992/93, and meet again in June 1994 to review progress. The terms of reference for the work to be done by correspondence were as follows:

- 1a. K Brander (UK) should continue assembly of the data on cod life histories solicited on behalf of the RPWG and the Study Group on Cod and Climate Change, calling on other members of the group for assistance as necessary, and aim for submission to ICES as a Cooperative Research report by the end of 1992.
- 1b. K Brander (UK) should coordinate an informal network of contributors to a literature data base on North Atlantic cod.
- 2a. S Campana (Canada) should prepare a brief state of the art summary on otolith microstructure following the symposium in South Carolina in January 1993. This should be circulated to members of the Working Group and submitted as a paper at the ICES Statutory Meeting.
- 2b. J Beyer (Denmark) and S Campana (Canada) should work together to determine if sufficient information exists to develop an analytical model of otolith growth, and if so, to begin developing a model.
- 3a. J Beyer (Denmark) should coordinate the assembly and coding of candidate larval growth models for evaluation and testing at the next meeting.
- 3b. S Tilseth (Norway) should make available the raw data from cod rearing experiments referred to in the document ICES CM 1989/EMEM No 1, and cooperate with J Beyer (Denmark) in the testing of candidate growth models.
- 3c. Initial simulation results based on the Norwegian data should be circulated to members prior to the next meeting, and further testing and parameterisation carried out during the meeting.
4. P Munk (Denmark) and J Modin (Sweden) should solicit data sets on size at age for larval fish from Working Group members. The data should be assembled in a standardised form together with information on temperature and prey availability at sampling sites. During the next meeting, inter-species and inter-regional variability in growth should be investigated with the emphasis on the influence of temperature and prey availability.
5. The Chairman of the RPWG should coordinate the preparation of a progress report on inter-sessional activity as a document for presentation at the 1993 ICES Statutory Meeting.

6. ICES should co-sponsor with other interested organisations (eg IOC/SCOR) a Study Group on Spatial and Temporal Integration which should meet in Scotland in 1993 (Chairman: Professor W Gurney), with the following terms of reference:
- a) consider and report on methods of statistically characterising the temporal and spatial variability in populations of larval fish and their prey and predators.
 - b) consider and report on the feasibility of integrating temporally and spatially variable abundance and vital rates over population time and space scales.
 - c) consider how sub-grid scale temporal and spatial variability in abundance and rates may be represented at the grid scale in marine ecosystem models.
 - d) consider methods of determining the most appropriate temporal and spatial grid resolution for models of fish recruitment.

II. PROGRESS REPORTS FOR INDIVIDUAL TOPICS, 1992/93

1a. **Assembly of Cod Life Histories Data Base**

K Brander (UK) has reported that assembly of the cod life history data base has continued, with more receipts of information since the last meeting of the WG and now includes data from 25 stocks. It has not been possible to achieve the intended schedule of publication as a Cooperative Research Report, but K Brander is still working towards this objective.

1b. **Cod Literature Data Base**

A literature data base on cod has been established by K Brander (UK).

2a. **The State of the Art in Fish Otolith Research and Application (Prepared by S Campana (Canada))**

While the otolith has a long history as a source of yearly ages used in fish stock assessments, its recent history indicates that it is destined for much more. Otoliths are now being used for everything from stock identification to mass marking, while examination of the microstructure has become a key component of most recruitment studies. These and other applications were discussed in depth at the International Symposium on Fish Otolith Research and Application, the highlights of which follow.

The Otolith Symposium was held 23-27 January 1993 on Hilton Head Island, South Carolina, USA. Convenors were J M Dean and S E Campana. More than 300 scientists, students and fishery managers, representing 29 different countries, attended the conference. The format was one of invited and contributed papers, workshops and technical sessions. The poster session was extremely well attended, given that all speakers were also required to prepare a poster. Selected papers from the proceedings will be published in a refereed hardcover book early in 1994.

The symposium centred around four theme sessions: Otolith growth and Morphology, Estimation of Fish Growth, Otoliths in Studies of Population Biology, and Chemical Tags and Otolith Composition. While some of the papers presented were descriptive or methodological, the majority were either hypothesis-driven or applied. Thus it was evident that the field of otolith research has matured to the point where it has become an accepted tool of fisheries biologists. Indeed, there were numerous examples where otoliths were being used in the direct provision of management advice, outside of the context of age determination. Image analysis is now a standard tool of the field. Highlights of the themes presented included the following:

- a) Recruitment - Most recruitment studies are now based on the larval or juvenile stage, and many of these require information on the rate of mortality or growth. Such rate measurements are now routinely obtained through examination of the otolith microstructure (daily growth increments). Frequency distributions of hatch dates, derived from counts of daily growth increments, are being increasingly compared with observed egg production schedules to infer dates of enhanced/reduced survival. Many now view hatch date distributions as one of the most promising means to get at the recruitment "problem".
- b) Stock and hatchery identification - Otoliths have been used with considerable success to differentiate among stocks, using a variety of approaches. Otolith shape, multivariate analysis of banding patterns and in particular, elemental composition, were particularly successful in this regard. A number of workers demonstrated successful discrimination of hatchery-reared versus wild fish based on the appearance of the otolith microstructure.
- c) Thermal and chemical mass marking of hatchery-reared fish - One of the fastest growing applications of otoliths. Millions of fish can now be inexpensively mass marked using calcium-binding fluorescent compounds (ie tetracycline or alizarin complexone) or temperature fluctuations to produce permanent marks on the otolith. The released fish can be recaptured days or years later and identified as to release date and batch.
- d) Age and growth determination - While this is a standard application of otoliths, its implementation has become much more accurate and precise. Validated daily and yearly age determinations are now commonplace, and have been used to demonstrate that scale age estimates are often unreliable. Annuli in tropical fish otoliths now appear to be the norm rather than the exception. Radiochemical age determinations appear to provide an excellent means of resolving longevity disputes involving difficult-to-tag fish.
- e) Size selective growth and mortality estimation - The chronological record of growth preserved in the otolith appears to be an excellent source of data for testing size-specific processes, particularly during the first year of life. However, the linkage between otolith and fish growth is still poorly understood and remains a potential source of error in growth back-calculation.
- f) Oceanographic influences - The time series of growth increments in the otolith are being increasingly related to parallel time series of oceanographic and climatic variables using multivariate and time series analysis. Use of strontium:calcium

ratios to construct temperature records is under dispute, but there is some suggestion of progress using oxygen isotope ratios.

In addition, papers were presented documenting otolith application to problems in archaeology, parentology, predator-prey relations, and evolutionary studies, while the factors influencing otolith and annulus formation continue to be of interest. The effect of ageing error on stock assessment accuracy is, if anything, more important than previously suspected.

2b. Development of an Analytical Model of Otolith Growth

S Campana and J Beyer have corresponded on the subject of the development of an analytical model of otolith growth. The consensus emerging from these exchanges seems to be that knowledge of the physiology of otolith deposition and its linkages to somatic growth is still too scant to support the development of a model.

3a. Coding of Larval Growth Models

No formal progress has been reported on the assembly and coding of larval fish growth models. However, one possible candidate, originally intended as a model of adult fish growth, has been developed in UK (Scotland) and may be adapted for application to larval fish.

3b. Availability of Norwegian Larval Cod Data

S Tilseth (Norway) has reported that raw data from cod rearing pond experiments has been collated and delivered to J Beyer (Denmark). No further progress beyond this has been reported.

3c. Circulation of Growth Model Results

No results from growth models are yet available for circulation.

4. Assembly of Larval Size and Age Data

No progress has been reported on this topic.

5. Preparation of Progress Report

This document represents a statement of progress on individual topics up to August 1993, based on information submitted to or gleaned by the chairman of the RPWG.

6. Study Group on Methods of Spatial and Temporal Integration

The Study Group on Methods of Spatial and Temporal Integration was held at the University of Strathclyde Business School, Glasgow, UK, between 14-18 June 1993, and was attended by 14 participants including several from the RPWG. The main conclusions of the SG were as follows:

- a) Data on spatial and temporal distributions of larval fish and their prey and predators are too sparse for the application of standard statistical methods of

pattern analysis. The most useful approach should be to develop mechanistic models of the processes underlying the distributions and design dedicated studies to test the models in the field.

- b) There is no universal prescription for aggregation or integration of data on fish larvae and their prey. Estimation of the uncertainty of individual data measurements seems to be the highest priority for development of such methods.
- c) A central consideration when choosing the spatial, temporal and trophic scale on which a given question can be asked must be the resolution of the data available to parameterise, drive and test any model. To be effective, models must be targeted at specific questions and tied closely to the available data.
- d) A suitable grid scale for modelling or sampling is one at which sub-grid scale processes assume second order importance. Theoretical work is needed to develop techniques for caricaturing the dynamics of sub-grid scale processes.
- e) Very often, models require driving data at a finer scale than is available from field sampling. In these cases, interpolation schemes should be used to generate fine scale input data, but these schemes must be based on a knowledge of the statistical structure of and/or the mechanisms generating the model scale variability. As a corollary, model studies should be used to help define optimal field sampling schemes.

The SG spawned many new ideas which will be relevant to the RPWG. Further digestion and discussion of the outcomes of the SG will be carried out among interested participants, in preparation for review at the next meeting of the RPWG.

III. SUMMARY

- a) Knowledge of otolith methodology and application has been consolidated. However, it has been concluded that there is insufficient knowledge available to proceed further development of an analytical model of otolith growth as envisaged at the last meeting of the RPWG.
- b) The Study Group on Methods of Spatial and Temporal Integration was successful in summarising the state of the art in relation to assimilation of field data from marine ecosystems into modelling frameworks. It is anticipated that further digestion of the SG report will lead to new approaches to investigation.
- c) Progress with the cod life histories check list is continuing, but the timetable for publication as a Cooperative Research Report has not been attainable.
- d) No activity has been reported on the assembly of size at age data sets for larval fish, and very little in the area of growth model development. Significant progress in these two areas is an essential pre-requisite for holding the next meeting of the RPWG, scheduled for Sweden in June 1994. Members of the WG committed to leading these activities will be requested to provide a firm timetable for the conduct of these tasks.

