Baltic Committee **ICES CM 2002/H:03**
Ref. ACE

Report of the

Study Group on Ecosystem and Multispecies Predictions

This report is not to be quoted without prior consultation with the General Secretary. The document is a report of an expert group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

https://doi.org/10.17895/ices.pub.9177

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

1 INTRODUCTION

According to Council Resolution CM2001/2H03 The **Study Group on Multispecies Predictions in the Baltic** was renamed to the **Study Group on Ecosystem and Multispecies Predictions** [SGMPB] (Co-Chairs: E. Aro, Finland, I Vuorinen, Finland, K. Sellner, USA) and it will meet for 4 days to:

a) compile basic information into the data-base for Baltic fish stock assessment and perform necessary key runs used by the Working Group on Baltic Fish Stock Assessment;
b) consider what is needed to estimate the carrying capacity of the Baltic, from an ICES perspective;

SGMPB will report by 1 June 2002 for that attention of the Baltic Committee and ACE.

These terms of reference were agreed during ASC in 2001. In contrast to these terms of reference, SGMPB suggested the following task for 2001 and 2002, which are given in SGMPB report. Their suggestions and proposals were largely not taken into account when setting up new TORs. SGMPB proposed the following:

1.1 Description and future tasks of SGMPB in 2001 and 2002 (reported in May 2001)

Because SGMPB is heavily dependent on development and outcome of various projects outside ICES, SGMPB considers that it is premature to propose any terms of reference for its next meeting.

However, SGMPB also considers that it is necessary to keep the capability of running multispecies models for the Baltic within the ICES community and should ensure further progress in multispecies modelling in the Baltic. In order to achieve this, following activities are needed in 2001 and 2002.

To promote the utilization of the MSVPA by the Baltic Fisheries Assessment Working Group as a standard assessment tool, the following activities are needed before the next Working Group meeting in April 2002:

- Installation of the 4M-program package as well as necessary databases on ICES computer system. 4M are currently ready for such implementation.
- Plan in 2001 and organize a training workshop in 2002 preceding WGBFAS meeting to increase the theoretical and practical skills of WGBFAS members on multispecies modelling issues in the Baltic.

In WGBFAS 2001 meeting, the stock assessment units of Baltic herring have been elaborated in order to achieve a better resolution of the local stock's dynamics. In order to assess the new stock units WGBFAS used MSVPA database to have necessary information for single stock assessments.

To have database revisions and to develop procedures for regular database update needs allocation of effort. Expanding the database backwards in time to cover 1960s and 1970s requires additional effort. In the present framework, this is not possible and thus it is necessary to explore in 2001 possibilities to set up an internationally co-ordinated project on compilation, validation and maintenance of basic multispecies assessment data for the Baltic stocks: The main aim of such a project should be as follows:

- validation of the newly compiled catch at age and weight at age in the catch data-base for the period 1974–1992 according to quarter and sub-division as a pre-requisite for finalization of a common multi- and singlespecies assessment database in the Baltic;
- exploration of the possibilities to expand the data-base back in time to 1960's and early 1970's including stomach data;
- set-up of a data-base on weight at age in the stock derived from historical and ongoing research survey activities;
- outline strategies and procedures for annual updating and maintenance of the database.

As basis of constructing environmentally based short-term prediction and medium- to long-term projection models, it is necessary to review available information on environmental processes affecting the population dynamics of cod, sprat and herring. For cod and sprat this review was completed in during this meeting. For herring a similar exercise is planned to be carried out inter-sessionally in 2001 and 2002. The aim is to:

- incorporate Baltic herring expertise into the SGMPB not available presently;

- structure and rank the relevance of major processes for predictions on different time scales under different environmental scenarios for Baltic herring stocks;
- give sources of information and necessary actions to include important variables and parameters in multispecies predictions.

The development, application and validation of different types of multispecies prediction models, which take into account environmental processes affecting prey selection and total food intake, growth, maturation and egg production as well as subsequent recruitment success have not been completed yet. Inter-sessional work should thus include:

- exploration of dominant mechanisms through which Baltic cod, sprat and herring recruitment, feeding, growth and maturation processes are influenced by fluctuations in the physical environment, both direct and indirect impacts;
- estimation of variations in transportation of cod larvae into environments of different habitat suitabilities;
- modelling of growth, sexual maturation and egg production of cod and sprat in relation to food consumption, food availability and environmental conditions in the framework of EU-project STORE;
- develop, apply and validate some new models for multispecies predictions, which take into account as much as possible abiotic and biotic processes.

SGMPB should inter-sessionally start to explore the feasibility of introducing statistically based spatial multispecies frameworks (BORMICON-type model) in the Baltic, allowing modelling of migration rates in comparison to observations from tagging experiments.

Finally, SGMPB should also explore possibilities to implement more simple multispecies models especially in view of uncertainties in catch at age and weight at age data (inconsistencies in age determinations) observed in recent years. One possibility is to explore Schaefer type multispecies production models. The major advantage of these models are that they do not require to resolve the age structure of the population, which seem to appropriate especially in the case of Baltic cod, where we still have a serious problem in age determinations.

As approved by Annual Science Conferences in 1999–2001, this Study Group and its predecessors concentrated initially on issues related to medium- to long-term multispecies prediction methodology and considered the development of different types of multispecies prediction models.

The new activities of the Study Group was considered to lead ICES into multispecies stock predictions, which take into account also environmental processes affecting species interactions and recruitment success and outline the necessities and strategies to expand the multispecies approach into an ecosystem approach.

This kind of approach has been considered to be of high priority for future management advice of ICES. The Study Group's tasks were furthermore expanded to explore the necessary actions to broaden the ecosystem modelling approach considering interactions to other ecosystem components and estimation of the carrying capacity of the Baltic and its various subsystems with respect to biological (including fish) production and review present activities on ecosystem modelling in and outside the Baltic Sea.

In addition to present membership, it was considered that extra expertise in Baltic herring biology and ecology must be integrated into the group to cover some important parts of the pelagic food web. The group also demands expertise in lower trophic level dynamics in the analysis of food web. To broaden up the expertise even further, participation from outside the Baltic was encouraged, e.g., by inviting persons involved in similar issues outside the Baltic Sea.

2 MEMBERSHIP AND ACTIVITIES IN 2001 AND 2002

2.1 Membership and empowerment of the meeting in 2002

The Statutory Meeting in 2001 in Oslo invited Delegates to nominate members for this Study Group. In the past, the group had seven members and in spring 2002, after the encouragement by ICES, total of eight members, of which two of the co-chairs have not been nominated as members for this group. One of the three appointed co chairs, a non-member co-chair had to announce his withdrawal of participation in Study Group's activities during spring 2002, the other co-chair, which was and still is the member of the group, did not have possibilities to allocate necessary time and resources for a meeting and the third one, also a non-member chair for the group was alone. In these circumstances it was considered, during the consultations between the Baltic Committee Chair and SGMPB member chair in April 2002 that with present set-up of TORs and with present membership and empowerment, there were no possibility to organize a successful meeting in 2002. It was also considered that it would not be very cost beneficial. These logistic difficulties

were the main reasons why the **Study Group on Ecosystem and Multispecies Predictions did** not met in response to its Council Resolution. However, there are also some other reasons not to organize a meeting at this time.

3 TERMS OF REFERENCE

3.1 Practicability of the Terms of Reference

The first TOR requested SG to:

a) compile basic information into the data-base for Baltic fish stock assessment and perform necessary key runs used by the Working Group on Baltic Fish Stock Assessment;

This TOR for SGMPB addressed the need of a meeting of this SG before WGBFAS meeting in April 2002 in order to compile and perform a multispecies key run for Baltic stocks especially in the Baltic Main Basin. However, in the present environmental regime and environmental circumstances of the Baltic Sea as well as the absence of the main predator, cod, it is virtually not necessary to update MSVPA key run each year. However, the predecessor of this present Study Group, **Study Group on Multispecies Predictions in the Baltic** met earlier in May 2001 and they compiled the data for year 2000 and performed necessary key run updated up to 2000 (ICES C.M. 2001/H:04). Their results were available at the WGBFAS meeting in Copenhagen in April 2002 and the results from May 2001 meeting showed just minimal changes in estimates compared to earlier estimates. This result was also expected, because of no changes in the abundance of key predator species.

As in previous years the natural mortalities used in WGBFAS assessments in 2002 varied between years and ages as an effect of cod predation. During 2002 meeting the new estimates of predation mortality supplied by SGMPB to WGBFAS were based on updated key MSVPA run made in May 2001 based on the updated information for 1999 and 2000. As the new estimates of natural mortality differed only slightly from the values used in 2001 assessments, the predation mortalities were kept unchanged. Thus the natural mortalities applied for year 2002 assessments for 2000 were the same as for the previous year and they were based on the Multispecies Virtual Population Analysis made by European Union project STORE in 2000 (STORE 2001). This decision not to change predation mortality values was sensible for the assessments of Baltic herring, sprat and cod stock in the Main Basin. The conclusion from this is that this term of reference was not very carefully considered during ASC in 2001, but may be very appropriate in other environmental conditions.

Secondly the Study Group was requested to:

b) consider what is needed to estimate the carrying capacity of the Baltic, from an ICES perspective;

This request is directly connected to Baltic Sea ecosystem and interactions between various trophic levels in the system. Many biological and physical processes are affecting population dynamics on various trophic levels modulating the carrying capacity of the system.

The following paragraphs try to cover some background aspects for the concept of carrying capacity and serve as a basis for further discussion in Baltic Committee sessions during ASC in Copenhagen in 2002. A new proposal is necessary to expand the tasks and reform the set-up and terms of reference of this Study Group to cover more of the Baltic Sea ecosystem aspects as well as to make the work of the Study Group more attractive to scientists inside and outside ICES.

4 CARRYING CAPACITY AND FOOD FOR THOUGHT

The classical concept of a “carrying capacity” is defined and it is dependent on the assumption of the existence of some kind of steady state. In the case of the Baltic Sea ecosystem and fisheries, this overview offers compelling evidence that nothing approaching a steady state exists and the system is moving from one state to another in continuous fashion.

If the ecosystem in the Baltic is moving from one state to another, then the carrying capacity of the Baltic Sea may be defined as a measure of the biomass of population/populations that can be supported by the ecosystem.

The carrying capacity changes over time with the abundance of predators and resources (food and habitat). Resources are in turn a function of the productivity of the prey populations and competition. Changes in the biotic environment affect the distributions and productivity of all populations involved.

Rather than measuring carrying capacity as an absolute value, which is changing all the time, or trying to provide a rigorous definition, the carrying capacity should be measured as an index that could be used to assess relative changes in the status of a population. In this context the size spectrum theory, which relates rates of productivity to the size class of organisms in the ecosystem, may be potentially valuable conceptual framework for examining carrying capacity questions in the Baltic Sea.

In the Baltic Sea the hydrographic complexity is considered to be low to medium depending on the area and mixing processes coincidental with regular autumn and spring mixing. The degree of trophic coupling is high because of short distance between trophic levels. The zooplankton community is considered to be complex, where both marine and freshwater organisms live side by side. The fish community in the open sea is considered simple and the exploitation rate of main fish species is rated from moderate to high depending on area of observation. The Baltic Sea is dominated in upper trophic levels by three major fish species (cod, herring and sprat). In this system coupling of reproduction and recruitment success to hydrographic processes and ephemeral inflow events has been described relatively successful in some cases and for example a clear relationship between the recruitment success of cod and the oxygen levels in the deep basins has been shown.

Typically, there are two different assumptions in modelling the structure and function of marine ecosystems.

- The first is based on the assumption that resource limitation or "bottom-up" factors are the dominant variables structuring ecosystems;
- The second one is based on the effect of predation or "top-down" processes within adjacent trophic levels.

In the Baltic both strategies seem to be relevant. The dominant mechanism controlling the ecosystem structure varies and is dependent upon the scales and time of observations. On large spatial-temporal scales, such as seasonal phytoplankton cycles bottom-up processes dominate, while on smaller scales, e.g., fish and zooplankton population dynamics may be dominated by predation.

In the Baltic Sea, as in all other marine ecosystems, the central scientific issues, when defining carrying capacity of the system may be listed as follows:

- Basic studies on and determination of primary- and secondary production and how they are capable to support higher trophic levels, pelagic planktivores and carnivores in response to climate variations;
- Regional scale ecosystem studies comparing how variations in climate affect species dominance and populations in the open sea and coastal areas.

The main processes, which modulate carrying capacity of the Baltic Sea ecosystem and the hypotheses may summarized as follows:

- Physical forcing: What are the main characteristics of climate variability: Is there possibilities to identify decadal or interdecadal patterns and why, how and when do they arise?
- Response of lower trophic level: How do primary and secondary producers respond in productivity, and in species and size composition, to climate variability in the regional ecosystems or different ecosystems?
- Response in higher trophic levels: How do life history patterns, population dynamics and distributions of higher trophic level species respond to climate variability?
- Ecosystem interactions: How are Baltic Sea and other ecosystems structured?

    * Do higher trophic levels respond to climate variability as a consequence of bottom-up forcing?
    * Are there significant inter-trophic and/or intra-trophic level and top-down effects on lower trophic level production and on energy transfer efficiencies?

The key research activities related to these issues should include *inter alia* retrospective analyses, development of ecosystem models and process studies.

In the Baltic Sea we can hypothesize that the climate change has very pronounced impact on the physical environment. At present, considerable natural and environmental variability exists on time scales from seasonal to decadal. This variability has a profound impact on circulation, salinity and oxygen content of the water column, mixed layer depths and the extent of ice coverage, all of which influence the rich biological productivity of the Baltic Sea. Thus the carrying capacity of the Baltic Sea is constantly modulated by the impact of climate change and variability.

These modulations rise following questions and a task list in connection to carrying capacity:

- What are the likely scenarios for climate change in the Baltic Sea and how would they influence the ecosystem?
    * Anthropogenic sources
    * Physical factors
    * Changes in brackish water habitat and thus changes in zoogeographic distribution of marine and freshwater species.
    * Magnitude and seasonal cycle of river flows with implications for coastal and open sea habitats

- Are there possibilities to detect and predict regime shifts and what is their impact?
    * decadal and bi-decadal scales
    * warm and cool eras and cyclic phenomenon
    * 30–60 year cycles and possibilities to measure ecosystem responses
    * interdecadal changes in the physical environment in late 1980s and early 1990s linked to large scale shifts in atmospheric processes.

- What is required to model the impact of climate change on the carrying capacity of the Baltic Sea
    * Spatially, temporally and by trophic levels nested models
    * coupled biophysical-ecosystem models

- To resolve questions concerning carrying capacity in connection to climate change, what are the appropriate spatial and temporal scales?
    * In the Baltic attention has been devoted mainly to interannual variations, but decadal and longer time scales may be more important for climate forcing and its impact on Baltic marine ecosystems.

The main research issues are to define means to increase understanding of the impact of climate change on: physical forcing, lower trophic level species, and higher trophic level species. Forcing questions should be focused at least on atmospheric forcing and the influence of bottom topography on coastal circulation and nutrient flux.

These scale factors influence important physical processes such as: mixed layer depth, mixed layer temperature, retention times (eddies) and turbidity. Research on the functional relationship between large-scale forcing and local conditions is necessary.

Lower trophic level topics include the effect of inflows/stagnation on the composition and production of plankton communities, the role of grazing and predation on the structure of plankton communities, trophic phasing, and climate change effects on over wintering plankton communities, and freshwater influences on plankton communities.

Potential research topics for higher trophic levels may be focussed on identifying climate change effects upon the species composition of fish communities, spatial distribution of predators and prey abundance as well as seasonality of resources to top consumers

5 NEXT STEPS AND RECOMMENDATIONS

In the present set-up and participation, it is unlikely, that the **Study Group on Ecosystem and Multispecies Predictions** [SGMPB] will be able to fulfil its tasks. It is then necessary to reconsider the fate and tasks of the group. Formulation of a new proposal for consideration of Baltic Committee and Delegates at the Statutory Meeting in Copenhagen is then necessary.

It is also essential for the future of this Study Group that nominated and appointed chair/co-chairs are available for this kind of activities and that they have their home institution's backup assured in advance.

If this Study Group will survive, it is vital to expand the TORs of the Study Group to cover more of the Baltic Sea multispecies and ecosystem aspects and also renaming of the group should be considered especially in connection to species interactions and carrying capacity issues.

Reforming of the set-up (chair and/or co-chairs and participation) of the Study Group is necessary.

New terms of reference for the Study Group should be carefully considered in order to integrate its tasks with the ICES Integrated Action Plan under discussion at the moment.

Reforming and reassigning tasks for this Study Group may also ease its general working conditions and make the work of the Study Group more attractive to scientists inside and outside ICES.

6 REFERENCES

ICES 2001. Report of the Study Group on Multispecies Predictions in the Baltic, Charlottenlund, Denmark, 7–11 May 2001; Baltic Committee ICES CM 2001/H:04, 108 pp.

ICES 2002. Report of the Baltic Fisheries Assessment Working Group. ICES Headquarters 15–24 April 2002, Advisory Committee on Fishery Management ICES CM 2002/ACFM:17, 547 pp.

STORE, 2001. Environmental and fisheries influences on fish stock recruitment in the Baltic Sea. (FAIR CT 98 3959). Consolidated Progress Report 1.1.2000 – 31.12.2000.