DRAFT Theme Session O – Spatio-temporal characteristics of fish populations in relation to environmental forcing functions as components of ecosystem based assessment: effects on catchability

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Introduction

The session was opened with an introduction, given by Doug Beare and summarized as follows: The ecosystem approach to fisheries management is currently very fashionable. The problem is that there is no consensus as to what it actually means and how regular, useful ecosystem/ fish stock assessments can be effected in practice given the huge data requirements and our general ignorance of the marine system itself. This is especially problematic in the world of fish stock assessment which is still stubbornly dominated by single species, cohort models based on the Baranov Catch Equation. Hopefully in the future more ecological (spatial, seasonal, meteorological, oceanographic, biological) data will actually be used in fisheries stock assessment. Clearly, understanding the interactions between fish and environment is extremely important. Unfortunately useful predictive models for fish stocks continue to elude marine scientists. Recruitment, for example, cannot yet be predicted reliably for any fish species based, either on the abundance of adults, nor on the environmental (abiotic or biotic) conditions, despite decades of research. Maybe, then, we should not be too ambitious as to what this Theme Session can achieve where, in addition to concerning ourselves with the question of how the environment interacts with fish behaviour and population dynamics, we are also interested in how these interactions affect our measurements of the system. That is to say, given all the potential for bias due to changing or adapting fish behaviour etc. how can we know that what we measure is actually related to what is there?

The presentations

The main questions considered by the theme session have been clearly expressed since the first talk by M. Frisk on winter skate in which were described declines in its abundance in the Western Atlantic. Migrations between the two main areas, probably caused by varying food input, were related to the population dynamics observed. Similar information was given by Guijarro *et al*. on the Mediterranean area. In the same way, it appeared clearly in the talk by E. Orlova *et al*. that the interactions between species (in this case, cod and capelin in the Barents Sea) presented complex patterns e.g. relating abundance and availability of capelin that could not be described by simple non spatial patterns. Spatio-temporal patterns appeared to be important for a wide range of species, ecosystems and trophic levels, as for instance the nekton community dynamics and the importance of hotspots off the coast of California which were described by D. Reese and D. Brodeur. The consequences of failing to properly take note of hotspots was emphasized and an important characteristics of such features in the ocean is of special importance: their remarkable spatial stability (i.e. they always tend to be in the same place) and their simultaneously temporal (ie. seasonal) dynamism in terms of species composition. Schooling patterns in pelagic fish were discussed in two talks, on herring in Norway (Langard *et al*.) and anchovy in Peru (Brehmer *et al*.) and the point that these represent highly complex systems that are difficult to quantify was stressed. Migrations were described as another important behavioural collective pattern with strong implication in the spatio-temporal characteristics of a given population (I. Studenov). Once recognized, the importance of spatio-temporal patterns, the capability to observe, record and monitor them appear as a critical issue. Technical tools are becoming more available for making spatio-temporal observations, as was expressed by Miksis-Olds in a description of the 'Ocean Groundfish Observatory' which highlighted new technologies that will potentially help

measure spatial patterns, aggregations in fish and reduce the potential for biased measurement due to changing behaviours. Besides technical improvements, methodological tools are needed. Different statistically based habitat modeling techniques were described in a range of presentations (S. Vaz *et al*.; A.Brown *et al*.; M. Woillez *et al*.) and the progress being made in these areas was very clear. Among the major results from the session we may highlight (1) the importance of habitat description, definition and understanding as showed by A. Brown *et al*. in their paper dealing with habitat definition and description in the Mediterranean; (2) the fact that spatio-temporal behaviour needs to be known in order to understand the functioning of the populations, as stressed through mathematical type modeling represented in E. North's talk on two species of oyster larvae; each of which with a completely opposite diurnal vertical migration behavior: the two behaviours produced very different settlement patterns in the Chesapeake Bay after their likely trajectories were tracked using an hydrodynamic model. And (3) the effect of these spatio-temporal patterns on the catchability, as clearly demonstrated by S. Kasatkina through the example of trawl catchability and D. Vasilyev on changes in catchability caused by year class peculiarities.

In conclusion the complexity inherent in marine fisheries was stressed. In particular this complexity is impossible to explain without exploring the spatial dimension. The relationship between behaviour and habitat was an important concept addressed during the Theme Session. It was apparent that sophisticated methods for 3D measurement and visualization are emerging and that these applications give good results which may be input into dynamic populations in definition of habitats. The importance of good knowledge of environmental and behavioral ecology was stressed (e.g. hotspots, Reese *et al*.; reproduction, Lingaard *et al*.). The Theme Session demonstrated the effect of spatial characteristics on catchability and on our 'fisheries indices'. It also highlighted how far we still have to go in understanding these processes.

Appendix

Original Terms of Reference for the Theme Session

Environmental factors force the spatial and temporal characteristics of fish distributions at various different scales; from individual school structures and dynamics up to basin level distributions. Characterization of these structures and their relationships to external forcing parameters can provide major insights into how and why these structures occur, and evolve. The ecosystem approach to fisheries management requires not only an understanding of how fisheries can impact management but also how environmental factors can affect our ability to monitor, assess and manage the fisheries themselves. This session is intended to focus on those aspects of fish distribution and behaviour which are responsive to changes in environmental conditions and which can then impact on our ability to manage these stocks. A simple example would be when a change in conditions prevents a given fish species remaining in the demersal zone; rendering it inaccessible to bottom trawls but at the same time more visible to acoustic surveys. This is not just relevant to surveys and management, but also to understanding changes in fisheries. Again, a simple example would be the changes in distribution of a key commercial fishery in response to a warming ocean.

The theme session, therefore, will focus on how the behavioural and ecological patterns of fish adapt to environmental changes (e.g. spatial structures, schooling, avoidance reactions, reaction to fishing gear, multispecies interactions, etc.), leading to changes in catchability in its widest context; ie. its importance to both the organisation and planning of research surveys and the interpretation of commercial landings data. We are particularly interested in presentations that make use of such understandings to inform management advice; but straightforward papers that simply describe the type of relationships outlined above are also welcome.