TIME VARYING EXTENSIONS TO THE CHARMINGLY SIMPLE MODEL OF THE NORTH SEA THAT CAN OPERATE IN EITHER TRAIT BASED OR SPECIES BASED MODES AND THAT CAN BE USED TO FIT NEW TYPES OF DATA.

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Introduction:

The Charmingly Simple Model (CSM) was originally conceived as a size and trait based steady state model. Its simplicity enabled it to show a clear relationship between overall fishing mortality and size spectrum slope, an emergent property of the North Sea multispecies system. It also provided insights into the basis of the coexistence problem. This provided a strong motive to extend the original model to a transient form to consider how emergent properties such as size spectrum slope or the large fish index (LFI) might change as fishing mortality evolves. It also proved tempting to consider if it could be written in a compact moment based formulation instead of in terms of size. A further interest was to include real species rather than their trait based cartoons in order to use it for predictions and to see if including new data such as trophic level data enhanced the model or not. These stages have each led to complications of the model. This raises the question to what extent is the added reality beneficial to understanding systems?

Mode 1：The CSM as a transient trait based model.

This is used to examine size based features of the North Sea fish ecosystem. The model adopts a unique structure based upon the 0th : 4th moments of the size distributions of 13 trait based "species" with L∞ ranging from 10cm to 130cm. For some purposes the moments are converted to size distributions.

Figure 1A. shows model simulations of results for the size spectrum slope (***) compared to the IBTS survey (xxx). Other lines are for simpler models.

Figure 1A

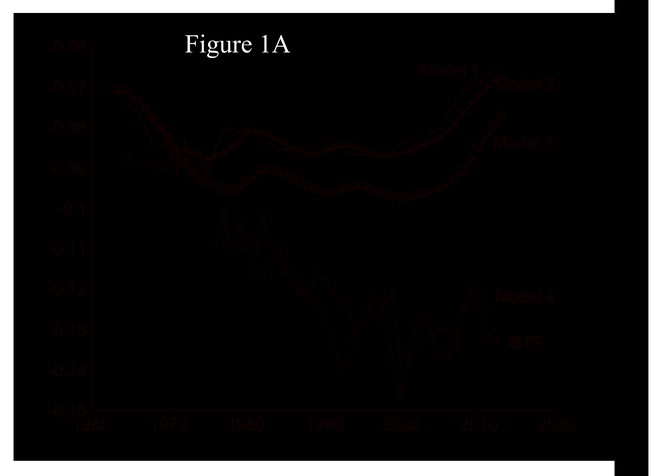
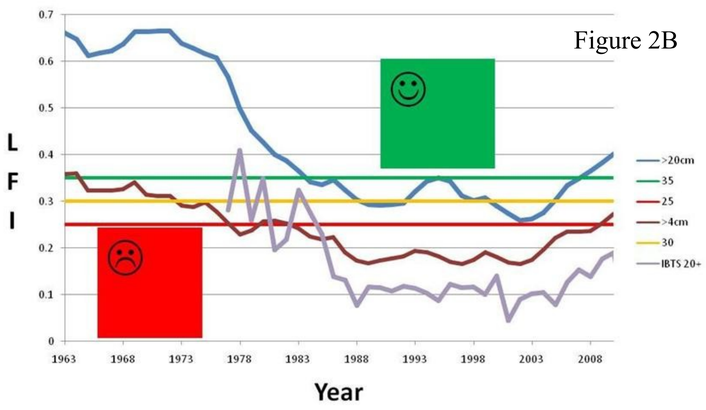


Figure 2B



Left Figure 1B shows two model based results for the Large Fish Index (—— ——) compared to the survey (——).

Mode 1. Conclusions:

This simple model has predicted 2 broad ecosystem metrics rather well. It indicates they respond slowly to mortality changes. It also exhibited (not shown) an intriguing ability to reproduce the gadoid outburst of the 1970's. This is probably because all fish "species" have the same size preference and thus small "species" can prey on the young of larger "species" within the size range of the model. This suggests that for some purposes "simple is good for understanding systems"!

Mode 2: As a predictive multispecies model.

The model reformulated in terms of 10 North Sea fish species. It remains a moment based model. It is used initially to emulate the more complex SMS model and to provide alternative inputs both to predictions and the T-ONS model. It is potentially a tool for exploring alternative hypotheses about the effect of recruitment processes.

Figures 2A-C. show the tuning of the CSM biomass (***) from 1994-2013 compared to SMS (—) for 3 of the 10 species and the predicted biomass and catch for years 2014-58. Predictions are made at Fmsy under the assumption of constant recruitment (biomass ooo, catch ooo) and also with a S/R function (biomass ooo catch ooo). This leads to very different outcomes for the three species illustrated. Note that the CSM tuning for the herring is poor in the last years and clearly needs further work. However, it is remarkable that a multi-species model can be based successfully upon the 0-4th moments of each species length rather than upon age or length. This leads to a common, parsimonious description for all species that may help with including data poor species in the future.

Figure 2A

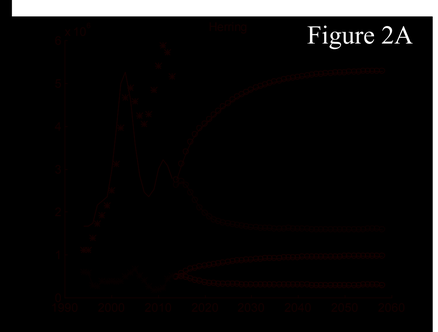


Figure 2B

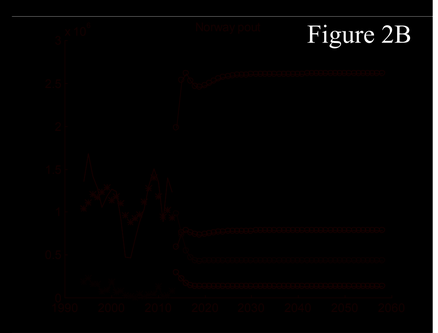
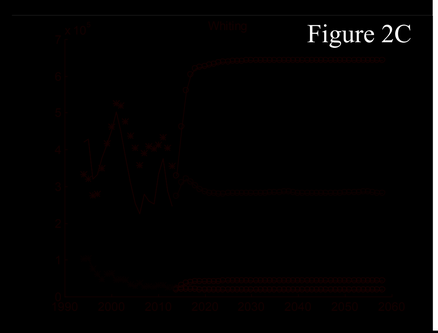


Figure 2C



Mode 3: The CSM used to model trophic level data.

The trophic level data were collected by CEFAS in the years 2002-06 and were kindly made available to the project by Simon Jennings. The data were converted from weight to cod equivalent lengths, smoothed and extrapolated to cover the length range modelled. The CSM was modified to depict smaller food and to calculate trophic levels for the modelled fish species. The results seen below suggest the CSM has reasonably successfully fitted this data. However, the price in complexity and run time was high. Relative to stomach content data, the trophic level data added scant information on feeding. But intriguingly trophic level decreases for big herring. Why? .

Figure 3A

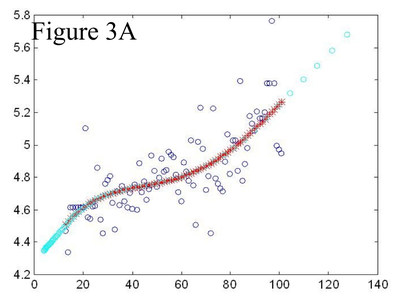


Figure 3A. (above) Shows the trophic level data for North Sea cod by length (o) together with smoothed mean values (*) and extrapolated values (o)

Figures 3B-E. (below) Show, by length, the mean trophic levels of the data (*) and the modelled trophic levels (*) for four species of fish that feed on different food types.

Figure 3B

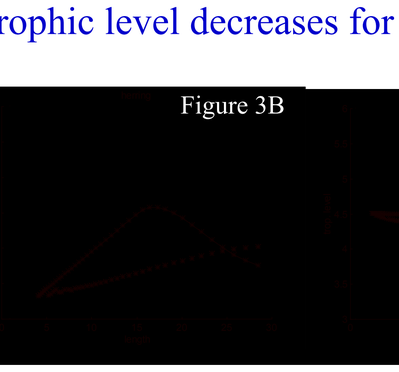


Figure 3C

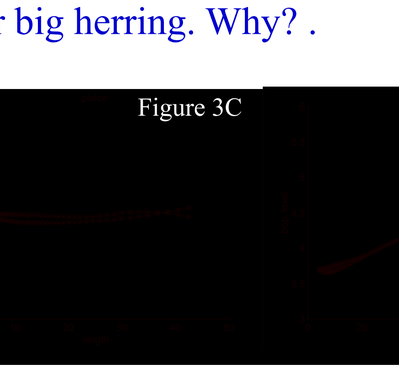


Figure 3D

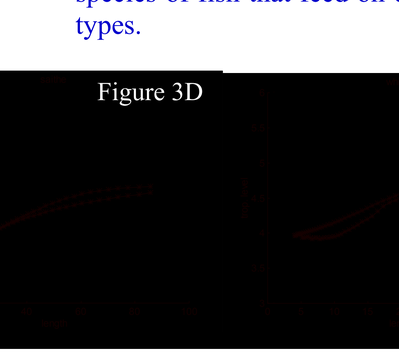
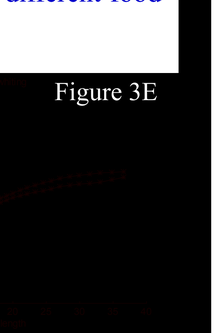


Figure 3E



Discussion: The Charmingly Simple Model was initially intended as a tool to aid understanding of complex multispecies models. The trait based model (Mode 1) follows most closely this ideal by providing understanding of ecosystem descriptors. Moreover, in this mode it appeared to explain the Gadoid outburst by size interactions. The complexity of modelling real species as seen in modes 2 and 3 tend to detract somewhat from its charm. However, one important insight arising from modes 2 is that predation is mostly expressed through modification of recruitment. The way predation changes yield via changes in recruitment, Y/R and SSB/R needs investigating. Moreover results from the herring trophic levels seen in mode 3 suggests the possibility of significant predation by young herring on larval fish. This is a interaction that falls between the cracks of most models. A new CSM beckons!

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