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Modelling the Spatial Distribution of Herring in the North Sea

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As part of the VECTORS project, a North Sea ecosystem model is going to be built and the spatial distribution of herring has not yet been implemented. Hence, it would be desirable if the distribution could be linked to simple oceanographic models to combine it with other earth system models, which was investigated in this study. The aim was to model the spatial distribution of North Sea herring based on the physical habitat properties temperature, salinity and depth, which are also part of all oceanographic models. Based upon catch data from the International Council for the Exploration of the Seas (ICES) statistical models were used to determine which physical variables could predict herring abundances the best. For every year the best models were then taken to spatially predict herring abundances for the years 1991 to 2005. As best-fit models have a remaining, unexplained variance the influence of this "uncertainty" had to be investigated. Here, the unexplained variance was interpolated in space, which accounts for the influence of datapoints on their geographic neighbour. With this statistical technique, called Regression Kriging, the predictions could be improved by removing some of the uncertainty.
It was found that sea surface temperature in combination with a stratification proxy gave best estimates for the spatial distribution of herring. These covariates are promising candidates to parameterise herring distribution in a North Sea ecosystem model. Model predictions revealed two large scale fundamental habitats for herring: the northwest North Sea near the British coasts and the southeast. The distribution of herring in the latter was directly predictable with the models, whereas the northwest distribution displayed greater influence of neighbouring datapoints and hence larger uncertainty. It is thus possible to define general habitats of herring with only physical variables, but for concise ecosystem models other covariates like prey abundance are needed.

Uncertainty is a central, statistical point in this study. In biology, a physical model predicting biological parameters can never be accurate, because an organism may react unpredictably due to ,i.e. genetic infleunces. Yet in this study, a statistical, physical model was used, on purpose, to define a suitable, physical habitat for herring. Some of the uncertainty was accounted for by using an interpolation technique, which further constrained the habitats by interpolating the unexplained variance. As an example, it is more likely to find one person 30 meters next to a group of 1000 people than to a group of ten people. This solely statistical uncertainty was removed and revealed that the abundances of herring in the southeastern North Sea could be well predicted using the model, but abundances in the northwest changed considerably after unexplained variance had been corrected. Hence, the uncertainty of the model results were a signal itself meaning that other factors such as prey or predator abundance may have a greater influence on the distribution of herring in that region. This hypothesis is in accordance with the fact that both regions have different age structures, which affects the ability to deal with environmental stress.