Coupled 3-d biophysical modelling of the North and Baltic Seas

Ute Daewel[1], Myron A. Peck[1*], Irina Alekseeva[1], Mike St. John[1] and Corinna Schrum[2]

[1]Institute for Hydrobiology and Fisheries Science, Olbersweg 24, 22767 Hamburg/Germany
[2]Geophysical Institute, University of Bergen, Allégaten 70, 5007 Bergen/Norway

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Climate variability is known to influence marine ecosystem in both direct and indirect ways. Direct effects include changes in physical properties (e.g., temperature, stratification) while indirect effects can include subtle changes in prey resources and other trophodynamic interactions (e.g. Heath, 2005; Weijerman 2005). To incorporate the complex interplay among the different direct and indirect effects, we are using a variety of numerical modelling approaches. The ultimate goal of these approaches is to help predict the impacts of changing climatic conditions on the structure and function of the North Sea and Baltic Sea ecosystems.

Within "RECONN" we are focusing on climate impacts on the distribution and vital rates (survival, growth) of early life stages of marine fish species. We have developed and employed a suite of inter-linked models including: 1) an Eulerian coupled hydrodynamic / ecosystem (NPZD) model to provide both 3-d fields of hydrographical properties, and spatial-temporal variability in zooplankton prey fields, 2) a Lagrangian transport model to simulate temporal changes in fish cohort distribution, and 3) an individual-based model (IBM) depicting changes in fish early life stages vital rates. The IBM can include either (or both) non-feeding (egg and yolk sac larva) and feeding developmental stages. The latter is accomplished via mechanistic foraging and growth subroutines. The coupled model system has been applied to assess the impact of both short-term (months) to long-term (decadal) climate variability on vital rates of sprat (*Sprattus sprattus*) in the North Sea. The small pelagic sprat is a key "wasp-waist" (e.g., Cury *et al*., 2000) clupeid species important to both "top-down" and "bottom-up" processes in the North and Baltic Seas (e.g., Köster & Möllmann, 2000). Coupled model output includes not only information concerning the interplay of temperature and prey availability on fish early life stage survival and growth but also on the mechanisms underlying

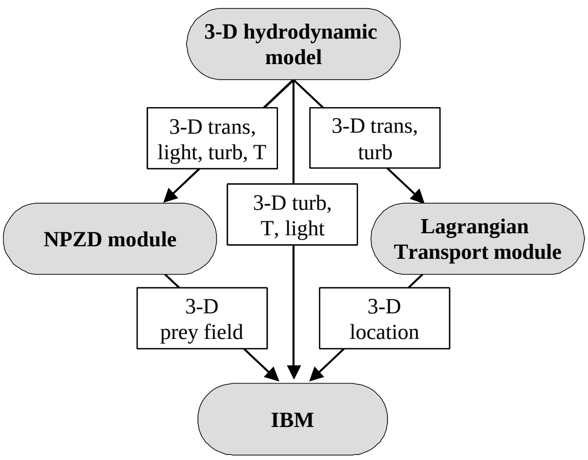

Fig.1: Schematic diagram of the inter-linked model system. A hydrodynamic model provides information about physical factors to three different inter-linked modules. 1. NPZD (Nutrient, Phytoplankton, Zoo-plankton, Detritus): calculating phytoplankton and Zoo-plankton dynamics; 2. Lagrangian transport module: calculating the location of individual larval sprat in the 3d-model area; 3. IBM (Individual based model) calculating individual larval growth and survival.

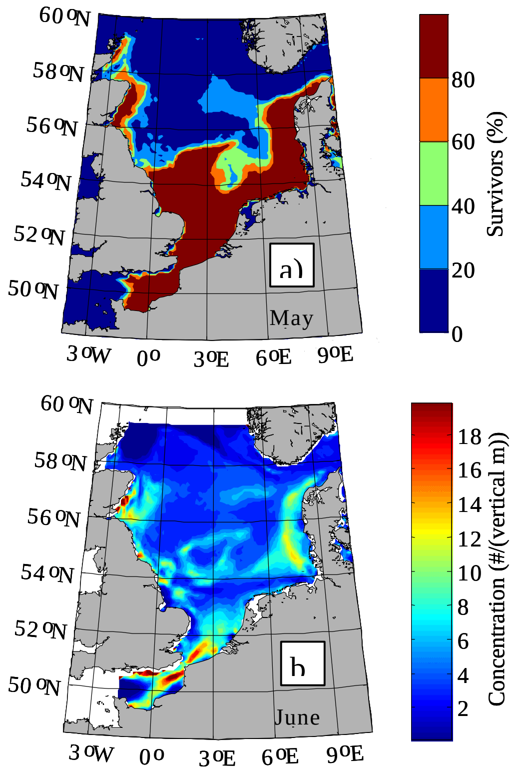

Fig. 2: Model results from a 3d-application in the North Sea in 1990. a) potential survival of sprat larvae versus spawning location and time: The results indicate a favourable area for sprat larval survival in the shallower areas of the southern North Sea, assignable to higher prey availability (zooplankton production). b) larval distribution: Larval accumulation was estimated to appear in the frontal areas in the North Sea.

*correspondence: myron.peck@uni-hamburg.de

patterns in spatial distributions (e.g., aggregation within frontal zones). Good agreement between modelled and *in situ* estimates of sprat distribution and growth rates in the German Bight suggests that interconnecting these different models provides an expedient tool to scrutinize the impacts of climate variability on fish population dynamics.

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