Ecosystem Change in the North Sea: Processes, Drivers, Prediction (ECODRIVE)

in the frame of BMBF-funded

MarinERA pilot call for international research projects on "Regional Drivers of Ecosystem Change: Description, Modelling and Prediction"

1. Objectives

ECODRIVE will assess, model and predict changes in the trophodynamic structure and function within the North Sea and thereby identify the drivers of ecosystem change. Drivers include those acting via climate change and variability as well as those acting more regionally via anthropogenic forcing (e.g., fisheries and eutrophication) to impact trophodynamic structure and function (i.e., functional biodiversity). Measurements include available long-term time series data on all trophic levels (from phytoplankton to fish), climate indices, as well as modelled (climate-forced) estimates of abiotic and biotic factors. ECODRIVE research focuses on fluxes of organisms and nutrients into the North Sea and will contrast advection through the channel versus transport into the region from the northern boundary (spatial analyses). A second objective will be to disentangle the contribution of decadal and multi-decadal forcing patterns to observed differences in the periodicity (temporal analyses) of changes in species abundance and composition in the study region. Understanding the drivers of ecosystem change at a variety of spatial and temporal scales will enable ECODRIVE to forecast future North Sea trophodynamic structure and function based upon different IPCC (climate) and anthropogenic (eutrophication, resource exploitation) scenarios.

ECODRIVE is designed to i) provide a better understanding of potential climate change impacts (scenarios), ii) enable the development of improved methods to quantify the uncertainty of climate change projections, iii) construct usable climate change indicators, and iv) improve the interface between science and policy formulation in terms of risk management (Phillipart et al. 2007). This proposal directly contributes to the objectives expressed by the European Science Foundation.

Long-term climate-driven physical processes have been simulated in the North Sea using hydrodynamic models (Schrum et al., 2003 see review by Lenhart and Pohlmann 2004). Models have undergone detailed assessment and validation, including the ability of models to describe observed low-frequency climatic variability in relation to atmospheric forcing and the impact of this on key hydrodynamic parameters such as SST, stratification, and salinity (e.g., Janssen et al. 2002). Coupled 3-D physical-biological models have also been developed by ECODRIVE partners that allow reconstruction of climate driven (high and low frequency) changes in the dynamics of bottom-up processes including NPZD (nutrient, phytoplankton, zooplankon and detritus) models (for review see Moll & Radach 2003). Bio-physical models have also been employed for key species at the tertiary level (e.g., larval & juvenile fish) to assess the relative importance of various mechanisms (Heath and Gallego 1998; Kühn et al. In press). Finally, North Sea trophodynamic relationships have been modeled for decades using 1-D ecosystem models (e.g., ECOSIM, Andersen & Ursin 1977) and, more recently, historical changes in upper trophic levels examined using detailed multispecies (4M/SMS) assessment models. At a recent (2004) ICES Symposium on North Atlantic climate change, it was concluded that progress made toward understanding climate impacts largely resulted from advances in bio-physical models, with more accurate and precise parameterizations of important biological processes, and utilization of higher level statistical models (Drinkwater et al. 2005). A similar conclusion was drawn by Stenseth et al. (2004) in their multi-authored monograph on marine ecosystems and climate variation.

In summary, changes in the species distribution, composition and relative abundance as well as in the phenology and trophic coupling of key members of the North Sea foodweb have been correlated with regional climate forcing (Beaugrand et al. 2003; Brander et al. 2003; Perry et al. 2005). Patterns of response are complex due to a mixture of drivers impacting both the internal dynamics of resident flora and fauna (ecophysiology and foodweb dynamics) and the input of (recolonization by) warmer-water species via changes in water advection (plankton) and/or directional shifts in the habitat (by larger invertebrates and fish). Estimates of climate-driven changes in physical structure (hydrodynamics) and the spatial-temporal variability in productivity of lower trophic levels (bottom-up forcing) as well as the trophodynamic structure and function of key predators (top-down forcing) are available from a suite of corroborated models. Simulations allow identification (and separation) of the most important climatic and anthropogenic drivers of change in North Sea functional biodiversity including drivers acting to influence both internal dynamics and the fluxes of organisms into and out of the system.