

A Stochastic Dynamic Foodweb Model for the Barents Sea

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How to reproduce key ecosystem properties with a simple model

Numerical models of marine ecosystem are notoriously difficult to construct because ecosystems are complex systems which detailed fundamental processes are poorly understood and quantified. In the face of such difficulties, we adopt a **simple modelling approach**.

The purpose of the stochastic dynamic food-web model (SDF) is to provide a **realistic representation of food web dynamics based on stochastic trophic interactions limited by a small set of constraints**. These include **mass-balance** (i.e. the conservation of mass within the system), **physiology** (i.e. satiation: the maximum amount of food intake of a predator per year per unit biomass) and **demography** (i.e. inertia: the maximum relative variation in biomass of a tropho-species per year). The SDF builds on the original idea of Mullan *et al.* (2009). We present here the first prototype of the model for the Barents Sea, which includes seven trophospecies and fourteen trophic interactions (Figure 1).

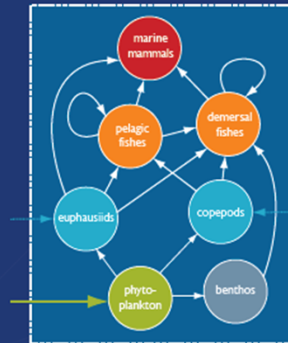


Figure 1. Food web topology of the SDF model for the Barents Sea, including seven tropho-species and fourteen trophic links. White arrows symbolise trophic links. The green arrow symbolises new primary production and blue arrows indicate import of biomass from the Norwegian Sea.

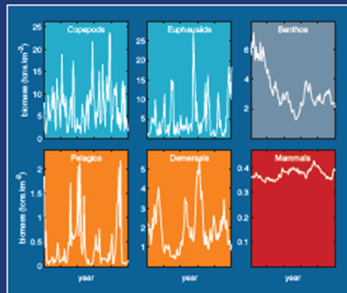


Figure 2. An example of 100 year biomass simulation of the tropho-species included in the SDF.

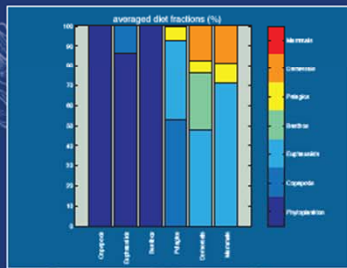


Figure 3. Mean annual diet fractions of the tropho-species included in the SDF.

References: Mullan, C., Fréon, P., Cury, P., Shannon, L., and Roy, C. 2009. A minimal model of the variability of marine ecosystems. *Fish and Fisheries*, 10, 113-119.



This simple model reproduces realistic biomass time series of individual trophospecies (Figure 2) as well as diet composition (Figure 3). SDF outputs also reveal density-dependence and functional trophic relationships (Figure 4), demonstrating that many of the properties that are observed in real ecosystems can emerge from stochastic processes operating within a very minimal set of constraints.

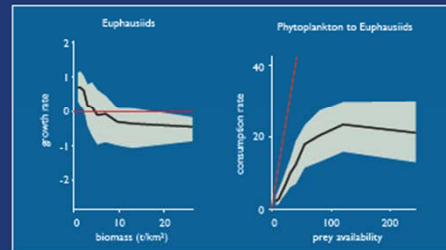


Figure 4. Emerging properties of the SDF. Left: emergence of density dependence for euphausiids, growth rates are positive at low biomass and negative at high biomass. Right: emergence of trophic functional relationship between phytoplankton and Euphausiids. The black thick lines show the median of 10000 simulation. The grey shaded area indicate the 25-75 percentiles of the growth rate and consumption rate distributions.

SDF model: Stochastic (trophic flows) Constrained (physiology, life history, mass- balance)



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