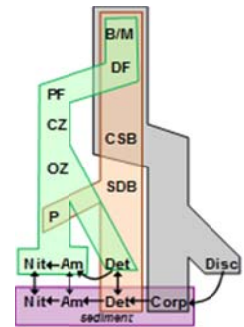


Strathclyde End-to-End Ecosystem Model (StrathE2E)

Model type:

The model simulates the dynamic responses of nutrients, detritus, and all the benthic and pelagic living components of a shelf-sea food web grouped according to coarse feeding categories, to changing natural oceanographic, environmental and anthropogenic factors. Connections between the components of the model represent biogeochemical processes, physiology, predator-prey relationships, transport and migrations. The model explicitly includes demersal and pelagic fisheries, and is particularly suitable for simulating the cascading effects of changes in human activity such as harvesting rates, or environmental factors such as nutrient emissions. The model represents regionally averaged properties at scales such as, for example, the whole North Sea. The model requires data on bathymetry, temperature, sea surface irradiance, turbidity, river inflows, and water transport and mixing rates derived from ocean circulation models. The model has been incorporated into a statistical fitting scheme called 'simulated annealing' which conducts thousands of simulation runs whilst randomly adjusting the parameter values, to seek the combination which provides the best match between the model results and assembled observations. These observations may include: nutrient concentrations, zooplankton abundances, fish and benthos survey data, fishery landings and discards, and bird and mammal diet compositions. Together these define the state of the ecosystem during the period corresponding to the environmental and human activity driving conditions applied to the model.



Existing Models for UK shelf seas:

The simulated annealing procedure has been applied to a North Sea version of the model corresponding to ICES area IV. This has been peer reviewed and published¹, and can be used online (<http://www.mathstat.strath.ac.uk/outreach/e2e/>). Additional versions of the model are available for the west of Scotland (ICES area VIa), and the Celtic Sea (ICES areas VII).

Existing uses:

- Simulation of fishery yields and MSY in the North Sea in relation to pelagic and demersal harvesting rates¹.
- Sensitivity of the North Sea food web to fishing and river nutrient inputs².
- Sensitivity of North Sea fishery yields to environmental drivers and biological parameters³
- Assessing cascading trophic effects of alternative fishery landing obligation measures in the North Sea⁴

Potential new uses:

- Simulating the whole food web impacts of ocean acidification.
- Disaggregating the effects of environment and fishing.
- Comparing fishery yields and MSY in different shelf sea regions (North Sea, West of Scotland, and Celtic Sea).
- Simulating the food web impacts of benthic disturbance by trawling.
- Projecting the cumulative effects of harvesting and environmental change.
- Coupling ecological model to economic and social models

Key modelling issues:

The model may be criticised for representing coarse groups of taxa rather than individual species, and only simulating dynamics at a coarse spatial scale. However, this is a conscious decision in order to produce fast computational speed and a minimal number of model parameters. Speed and minimal parameter count are key to enabling statistical fitting, which is lacking in the majority of other marine food web models. The ability to identify the best-fit parameter set yields a model producing results which are "as good as they can possibly be". The thesis is that coarse-scale results of this quality are preferable to more highly resolved outputs with little or no idea of how close they are to reality.

For further details contact: Prof Mike Heath (m.heath@strath.ac.uk)

¹ Heath (2012). Progress in Oceanography 102, 42-66.

² Heath et al. (2014). Ecology Letters 17, 101-114.

³ Morris et al. (2014). Ecological Modelling 273, 251-263.

⁴ Heath et al. (2014). Nature Communications 5, 3893.