Coupled Spatial Modelling (COSM) - food web effects due to structures and habitat change in the North Sea

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Objectives

**INSITE (a):** help establish the magnitude of the effects of man-made structures compared to the spatial and temporal variability of the North Sea ecosystem, considered on different time and space scales

**COSM**

1. To evaluate the habitat preferences of key functional groups of infauna, epifauna and fish
2. To develop a state-of-the-art modelling tool “Ecospace” that links spatial data layers with temporal food-web dynamics
3. To explore the role of man-made structures on the food web relative to natural variation and other pressures through scenarios
COSM in a nutshell

Habitat mapping
plus covariates and pressures

Development of modelling tool
production at structures and dispersal of mobile species

Simulation and Scenario testing
– change in habitat
– natural variation

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Ecopath International Initiative (EII)

Cefas
Natural habitat

- **sediment**
- **depth**
- **temperature**
- **salinity**

- **sediment**
  - Mud to muddy sand
  - Sand
  - Coarse substrate
  - Mixed sediment
  - Rock and boulders

- **depth**

- **temperature**

- **salinity**

(source: EMODnet)

(source: Defra DEM UK EEZ plus EMODnet bathymetry)

(source: MyOcean)

(source: MyOcean)
Artificial habitat

oil and gas

other

ship wrecks

(source: wrecksite.eu)
Evaluating the habitat preferences...

• How?
  For substrates and structures: simple proportion of cells (gridded) with habitat where species occur

For non-linear effects of structures, depth, temperature and salinity use output from statistical modelling using Generalised Additive Modelling

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Fishing trawl stations IBTS

Red: not present
Green: present
Benthic groups
occurrence of widespread functional groups linked to depth

Small mobile epifauna

Sessile epifauna

Ecopath
International
Initiative (EII)

Centre for Environment
Fisheries & Aquaculture
Science

Cefas
Statistical effects of structures on probability of occurrence of groups in survey data

green: likely occurrence is high when structures present

red: likely occurrence is low when structures present

larger bubbles indicating larger effect size
**COSM: objective 2**

To develop a state-of-the-art modelling tool that links spatio-temporal data layers with food-web dynamics.
Starting point

✓ **Ecopath** – a static mass-balanced snapshot

mass-balance = conservation of mass

Requires:
- production rates
- consumption rates
- respiration rates
- diet compositions

http://ecopath.org/
Temporal fitting

✓ *Ecosim* – a time dynamic simulation module

Estimate *vulnerability* of functional group to predator.

*Feeding time* effects

Apply time *forcing* functions

[www.ices.dk](http://www.ices.dk)

North Sea draws on 116 time-series

EwE ‘key-run’ (temporal) completed by Steve Mackinson, Clement Garcia, Christopher Lynam

Modelling spatial distribution (capacity)

Base habitat (prior knowledge)

Natural substrates (Additive effects of habitats)
Species affinities for natural habitats (based on proportion of the habitat sampled by surveys where the species is present) e.g. for turbot at mud/muddy sand value = 0.12 and mixed 0.32

Environmental effects (multiplicative effects, for turbot includes depth, temperature and salinity)

Artificial substrate (multiplicative, for turbot includes platforms and wrecks)
Species affinities for man-made structures (statistical model of probability of occurrence of species given natural habitat using gridded data 0.25 x 0.25 degrees) e.g. for turbot near pipelines value = 0

Avoidance/disturbance effects (multiplicative, for turbot includes platforms and wrecks)

Platform (area of grid cell)
Modelled habitat capacity

Attraction toward prey groups
- Mortality by predators and dispersal away
- Removals through catch by fishing

Final distribution herring

From capacity to distribution

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Ecospace simulation run to equilibrium
COSM: objective 3

To explore the role of man-made structures on the food web relative to natural variation (temperature as a driver for production) and other pressures (fishing).

Habitats (natural vs artificial)

Natural variation

Fishing impacts
Ecospace Model Scenarios

S1: No removal of structures (baseline)
S2: Complete removal of platforms and pipelines
S3: Complete removal of platforms, pipelines + cables
S4: Complete removal of platforms, pipelines, cables, turbines + wrecks

Hi F: No removal of structures, increase in fishing effort

Contrast change in biomass of groups near structures and in wider system
Replicate above scenarios with climate variability included
Results

Change in biomass of selected benthic functional groups at equilibrium

Biomass (platforms and pipelines removed) minus Biomass (baseline)
Results benthos

Regional estimates within the area occupied by platforms, cables and pipelines

Scenarios
Baseline: S1
Platforms + pipelines removed: S2
with and without natural variability: +V

Change in biomass of selected benthic functional groups at equilibrium with natural variability
Results

Estimates of biomass at equilibrium across the North Sea for selected management scenarios.
Results

Estimates of biomass at equilibrium across the North Sea for selected management scenarios

Contrast to potential effect of fisheries if return to 1990 fishing effort levels
Main findings: structures

Model simulations indicate that man-made structures have an effect on the local community composition and these effects can disperse throughout the North Sea ecosystem mediated by interactions between species.

The removal of oil and gas platforms and pipelines may ultimately contribute to declines in some groups (large crabs, sessile epifauna, skates, rays), but increases in others (small mobile epifauna, infaunal macrobenthos, sharks, flatfish and roundfish).

The presence of wrecks and wind turbines appears to have a much greater impact than oil and gas infrastructure on rays, sharks, sandeels, flatfish and demersal roundfish.
**Importance given other pressures?**

Modelled effects of structures are **minor for the majority of model groups compared to other pressures** such as an increase in temperature on the ecosystem or increase in fishing effort.

Additional habitat provided by platforms and pipelines may be relatively small, but this difference should not be disregarded **for non-commercial species of conservation concern**, since natural variability is by its very nature unmanageable and the mass removal of other structures such as ship wrecks is unlikely to occur.
Thank you for your attention!

And thanks to the COSM team!

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[Plus insight from Mark Kirby, John Shepherd and ISAB]