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

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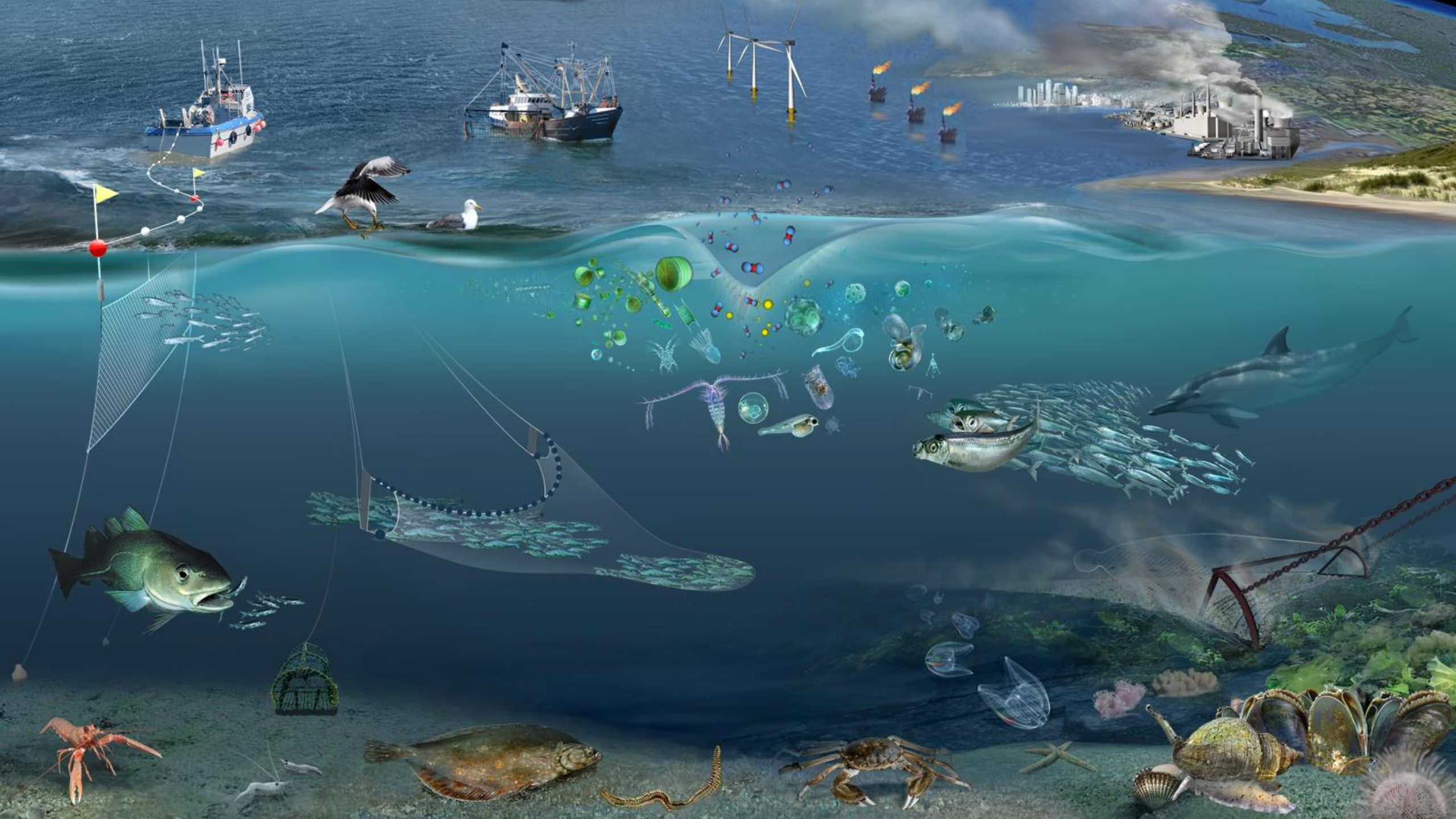
31st October 2017
The Kohn Centre,
The Royal Society,
London

Centre for Environment Fisheries & Aquaculture Science

Ecopath International Initiative (EII)

Cefas



Objectives

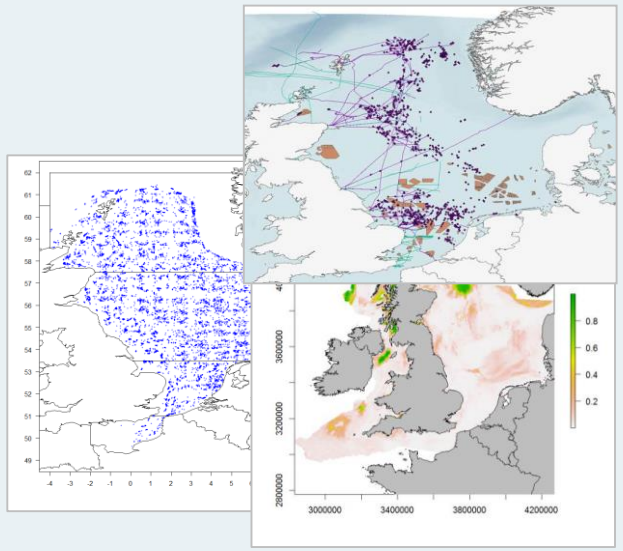
INSITE (a): *help establish* ***the magnitude of the effects of man-made structures compared to the spatial and temporal variability of the North Sea ecosystem****, considered on different time and space scales*

COSM

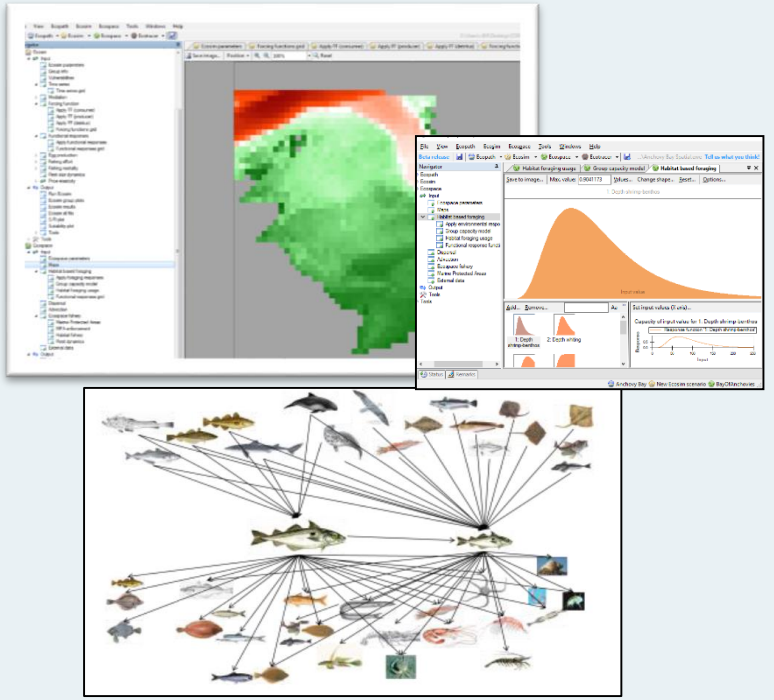
1. To evaluate the habitat preferences of key functional groups of infauna, epifauna and fish
2. To develop a state-of-the-art modelling tool "*Ecospace*" that links spatial data layers with temporal food-web dynamics
3. To explore the role of man-made structures on the food web relative to natural variation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

COSM in a nutshell

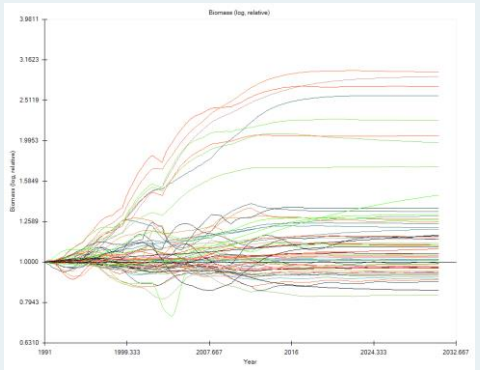
Habitat mapping
plus covariates
and pressures



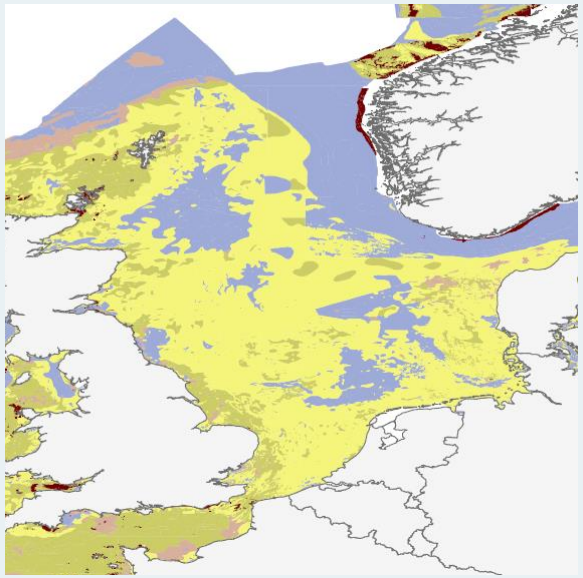
Development of modelling tool
production at structures and
dispersal of mobile species



Simulation and
Scenario testing
– change in habitat
– natural variation



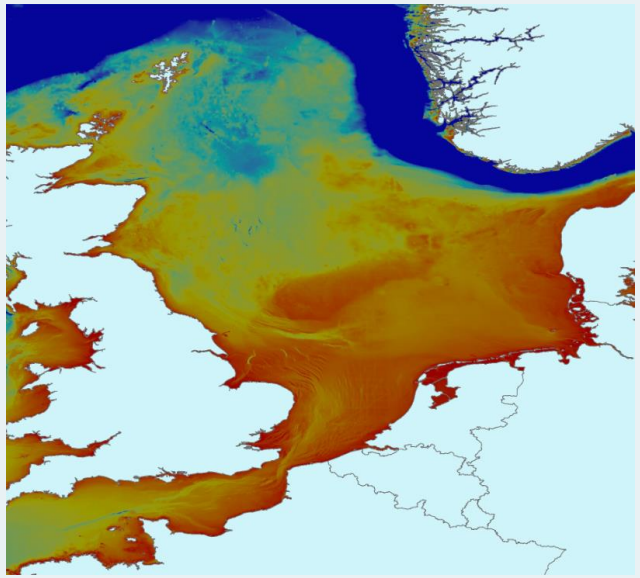
Natural habitat



sediment

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

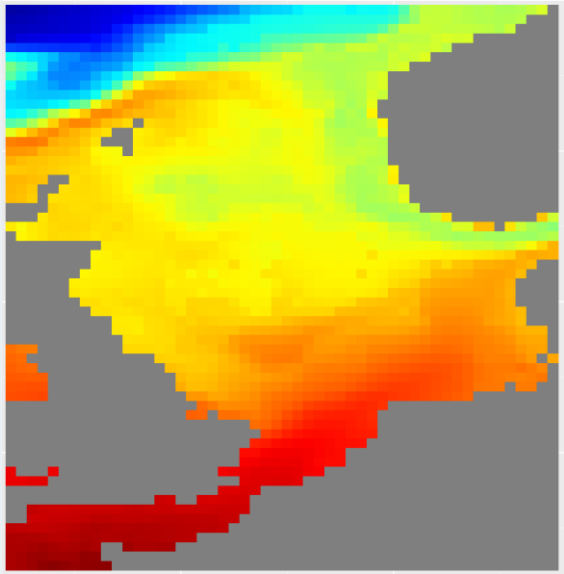
(source: EMODnet)



depth

0
100
200
(m)

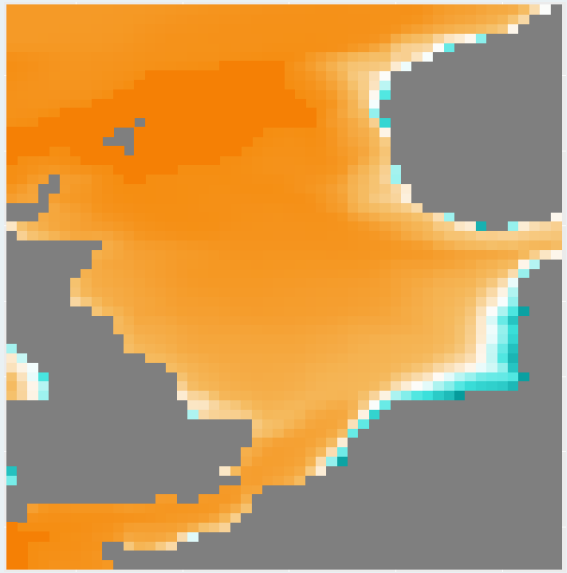
(source: Defra DEM UK EEZ plus EMODnet bathymetry)



temperature

12.5
10.0
7.5
5.0
(°C)

(source: MyOcean)



salinity

35
34
33
32
31
30
ppt

(source: MyOcean)

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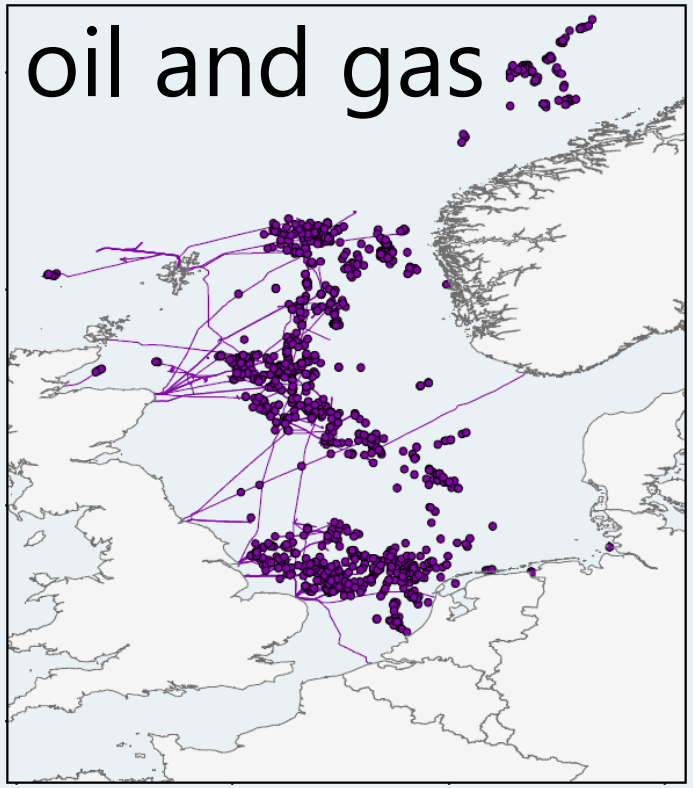
2006-2016

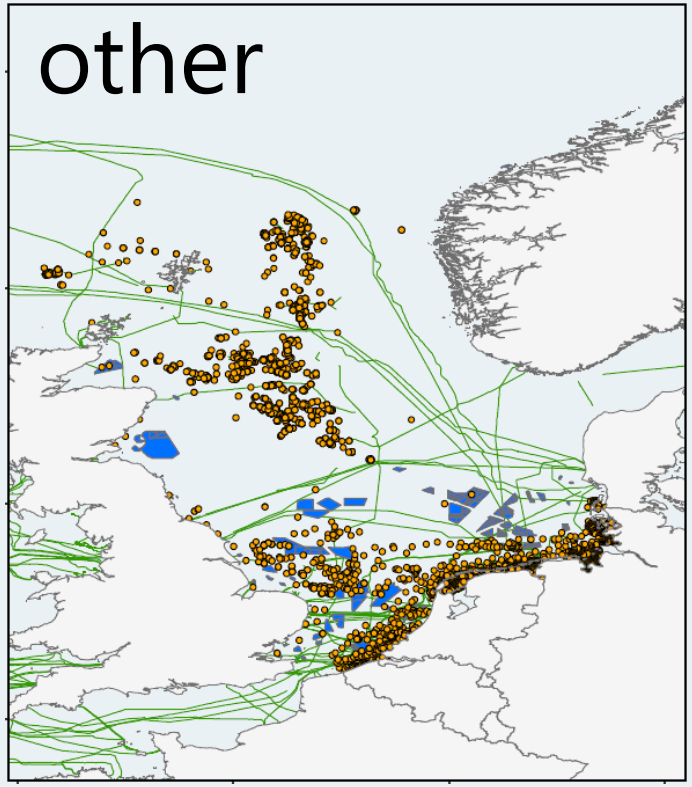
Ecopath International Initiative (EII)

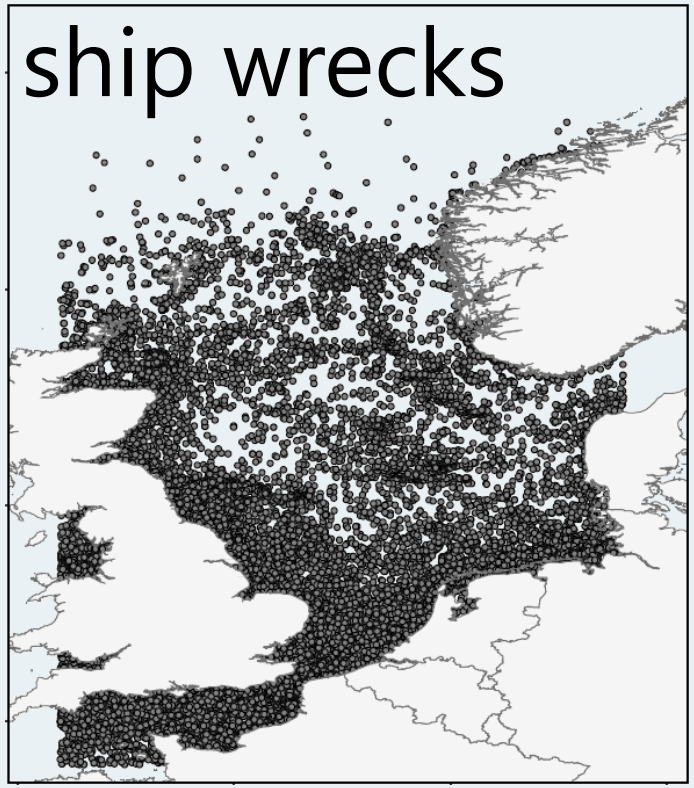
2006-2016

Cefas

Artificial habitat







(source: wrecksite.eu)

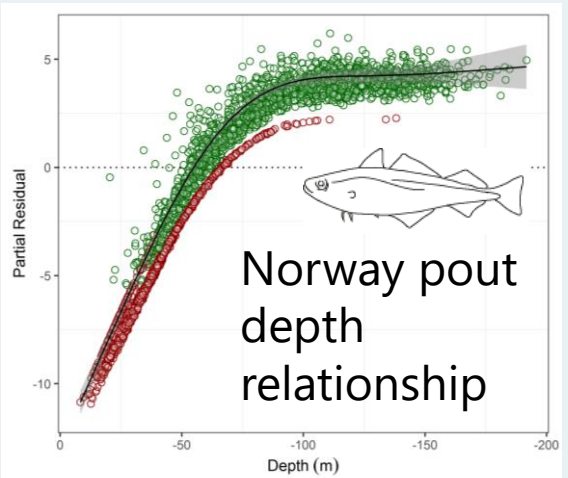
Evaluating the habitat preferences…

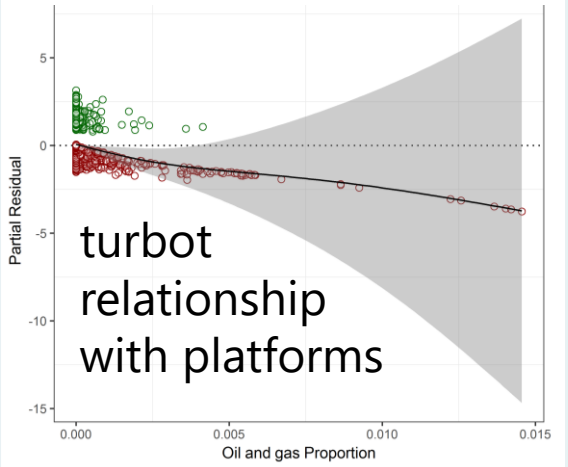
- How?

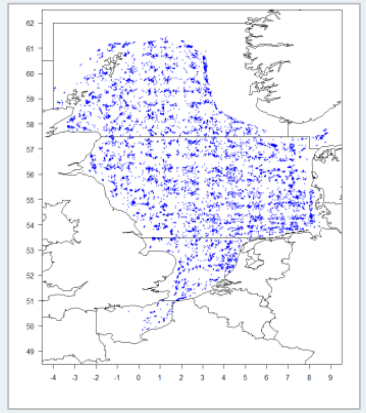
  For substrates and structures: simple proportion of cells (gridded) with habitat where species occur

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

frequency of occurrence







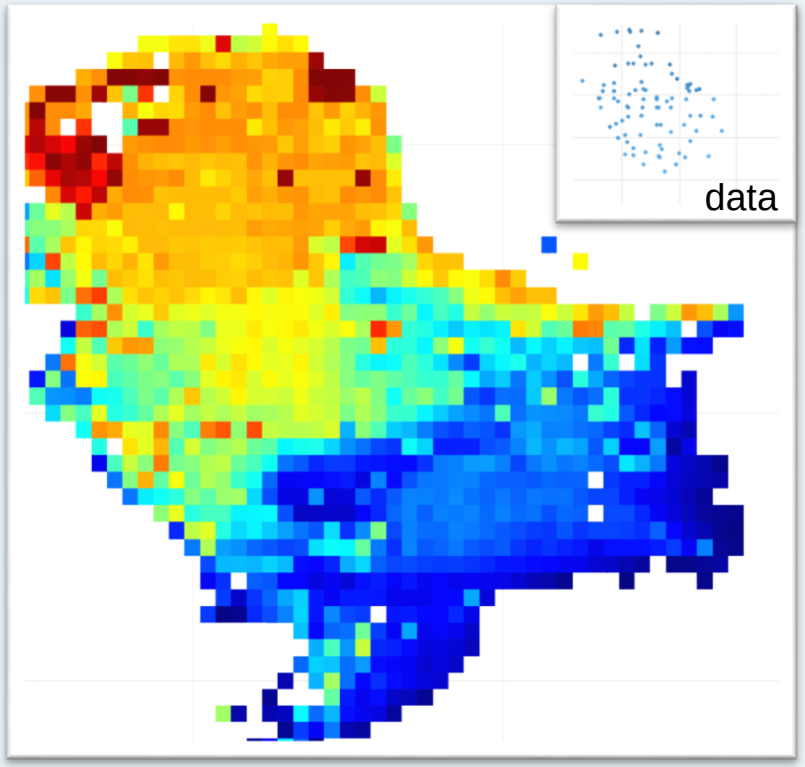
Fishing trawl stations IBTS

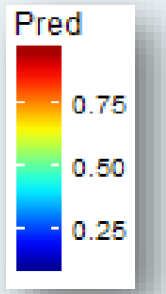
Red: not present
Green: present

Benthic groups

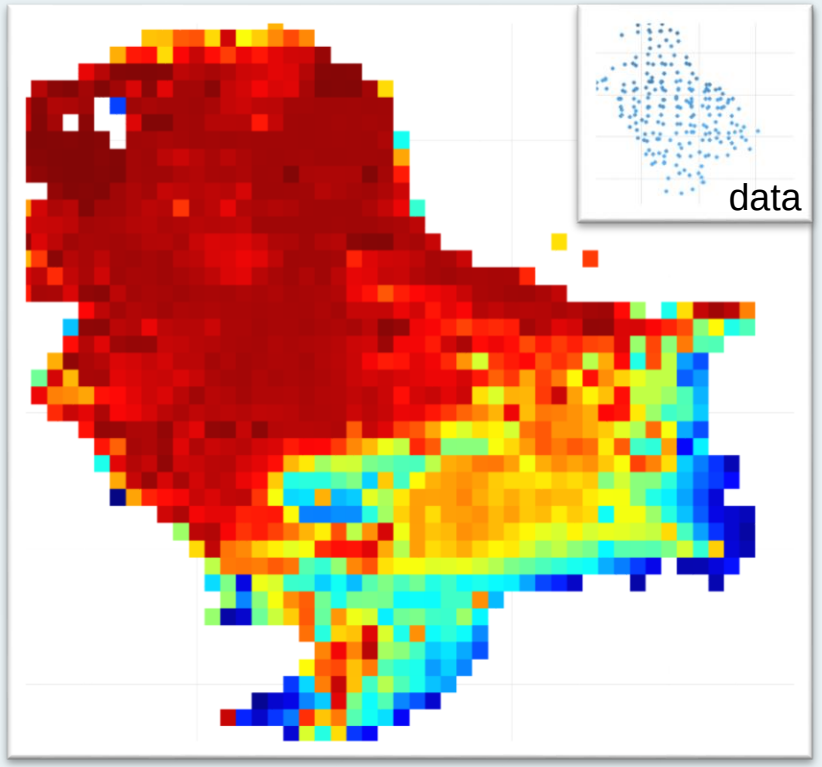
occurrence of widespread functional groups linked to depth

Small mobile epifauna





Sessile epifauna

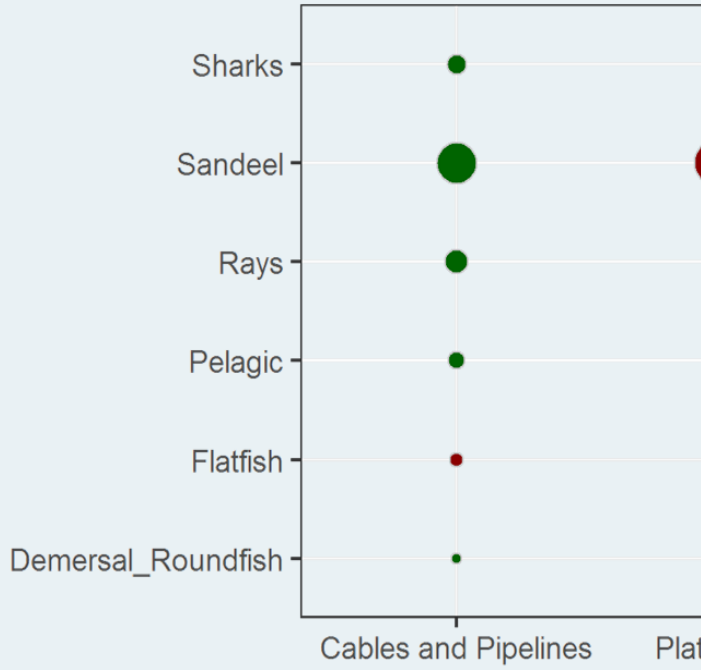


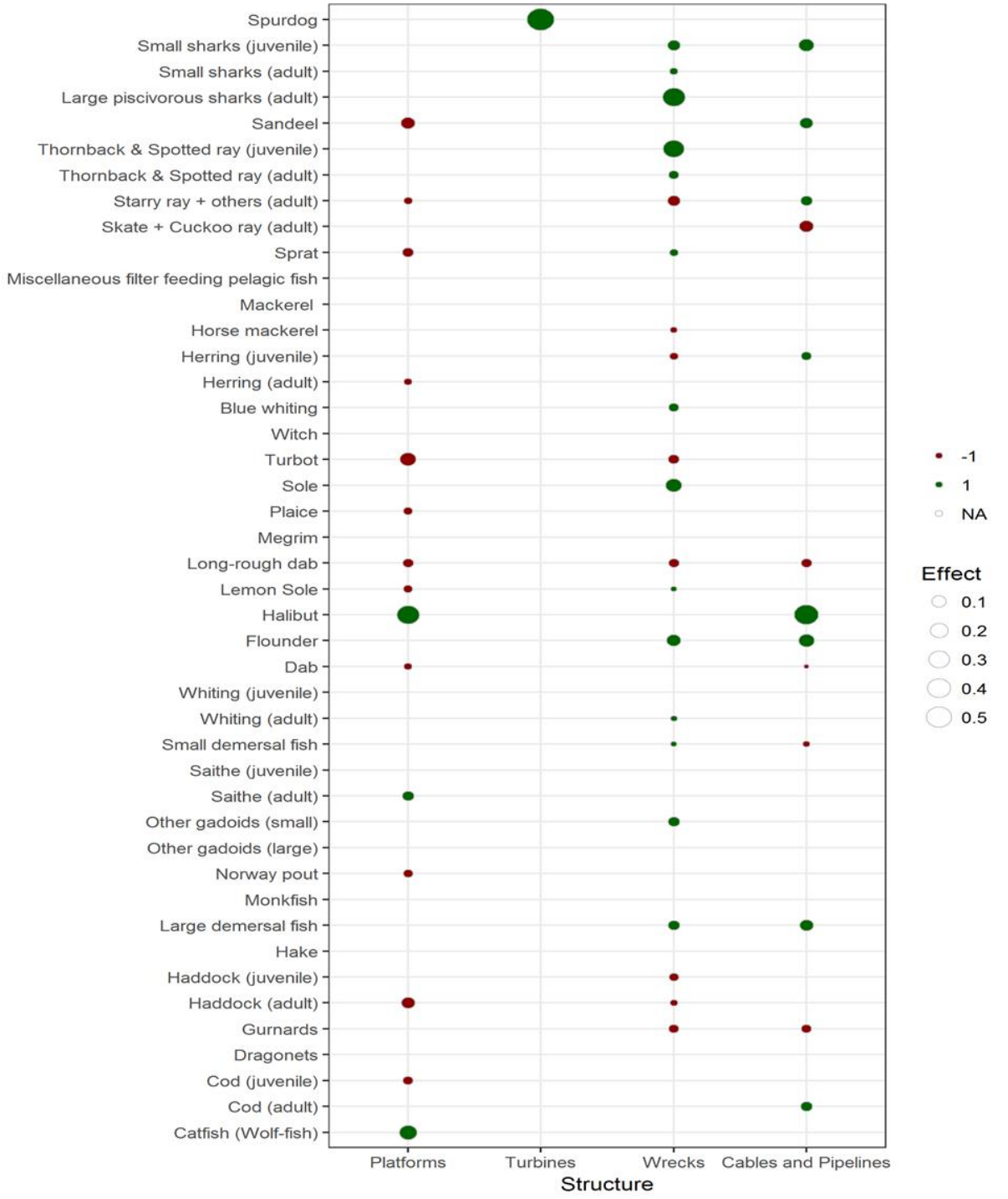
Statistical effects of struc
occurrence of groups in s

green: likely occurrence is high when structures present

red: likely occurrence is low when structures present

larger bubbles indicating larger effect size





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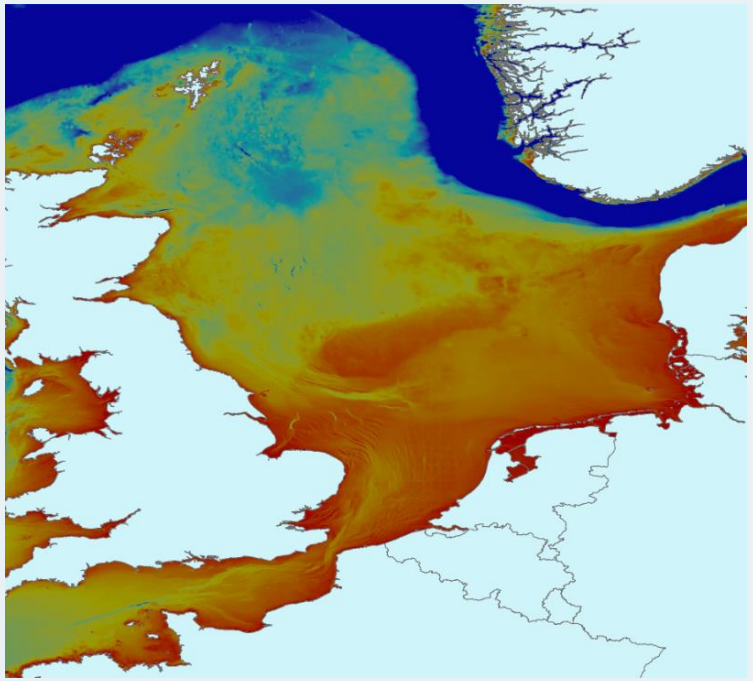
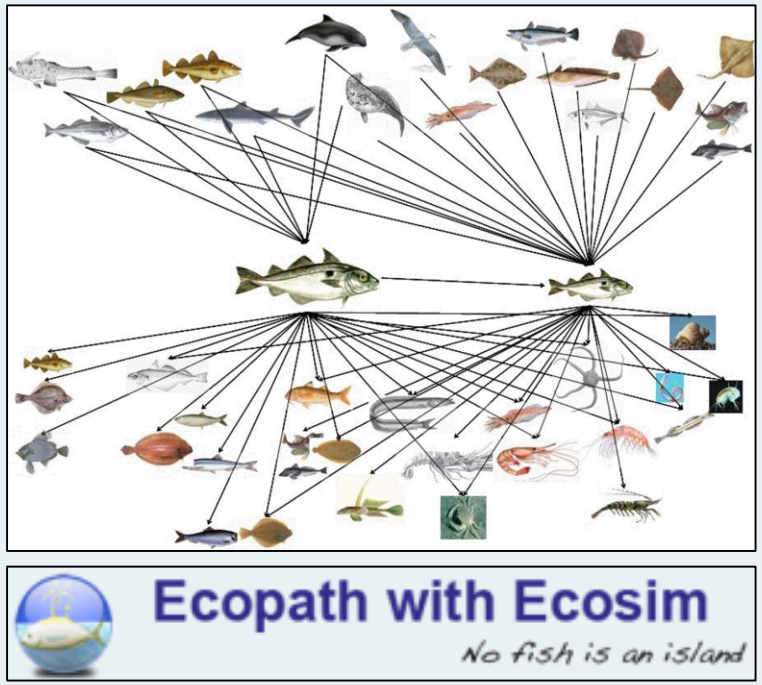
COSM: objective 2

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





The haddock perspective in the model

Starting point

Ecopath with Ecosim

No fish is an island

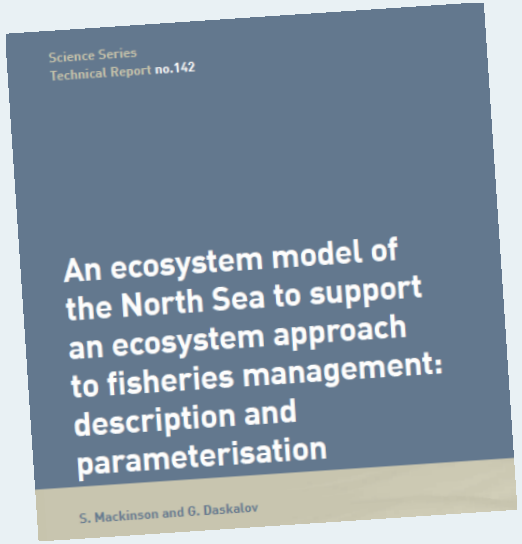
http://ecopath.org/

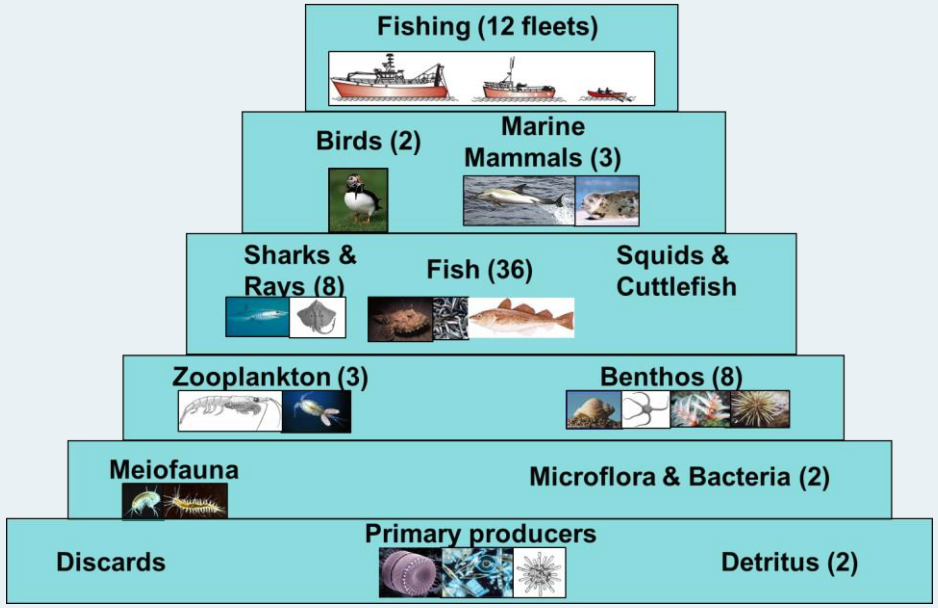
✓*Ecopath* – a static mass-balanced snapshot

mass-balance
= conservation
of mass

Requires:

- production rates
- consumption rates
- respiration rates
- diet compositions





Temporal fitting

Ecopath with Ecosim

No fish is an island

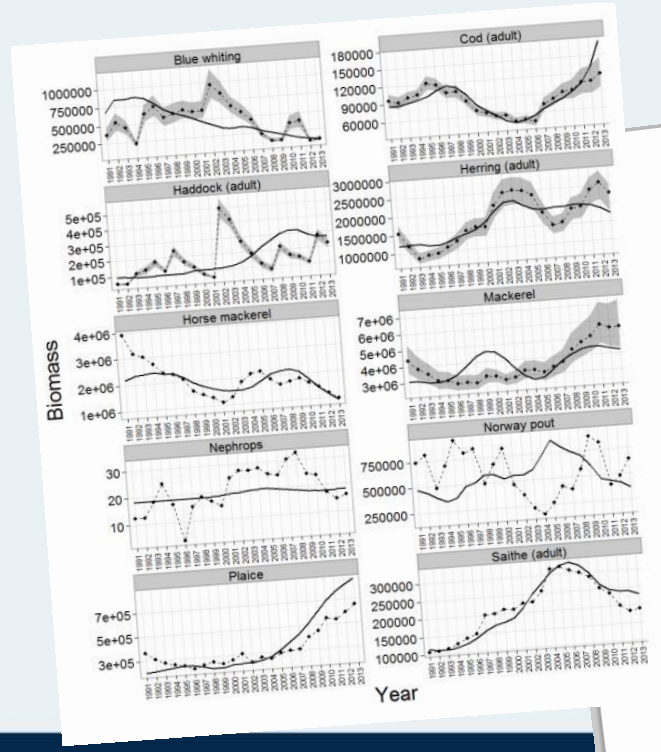
http://ecopath.org/

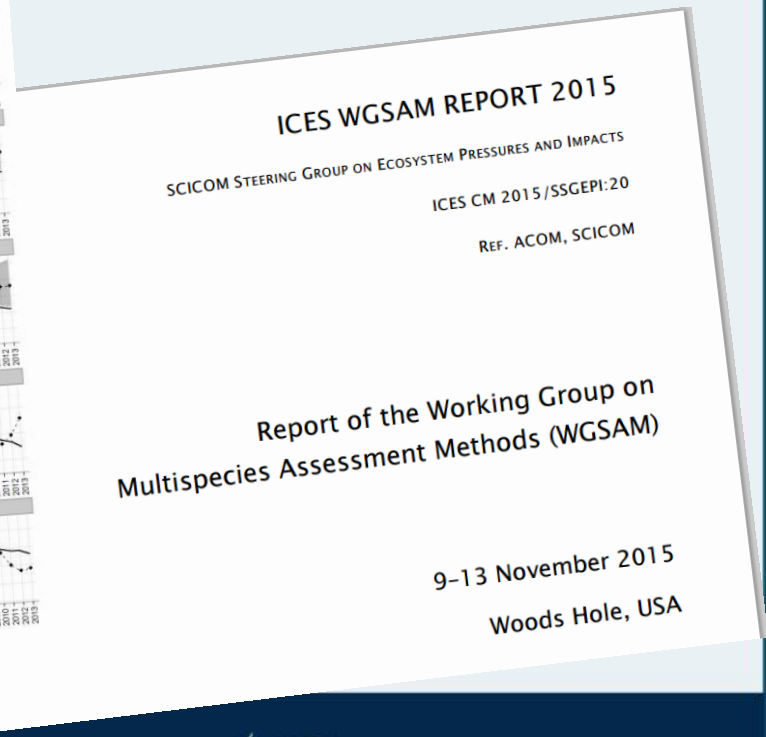
✓*Ecosim* – a time dynamic simulation module

Estimate *vulnerability* of functional group to predator.

Feeding time effects

Apply time *forcing* functions




ICES WGSAM REPORT 2015

SCICOM STEERING GROUP ON ECOSYSTEM PRESSURES AND IMPACTS

ICES CM 2015/SSGEPI:20

REF. ACOM, SCICOM

Report of the Working Group on Multispecies Assessment Methods (WGSAM)

9–13 November 2015

Woods Hole, USA

www.ices.dk

North Sea draws on 116 time-series

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

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Cefas

Modelling spatial distribution (capacity)

Base habitat
(prior knowledge)

x

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

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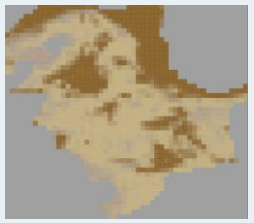
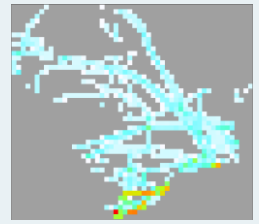


+

Artificial substrate

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

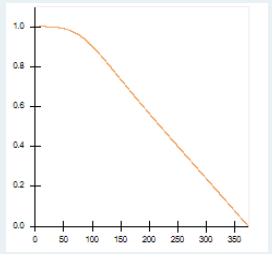
•



x

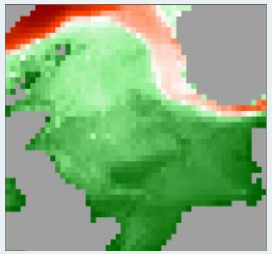
Environmental effects
(multiplicative effects, for turbot includes depth, temperature and salinity)

Habitat preference



depth (m)

•

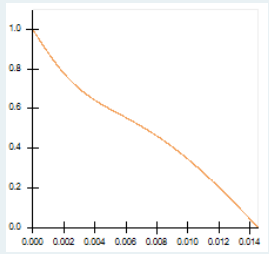


depth

x

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

Habitat preference



Platform (area of grid cell)

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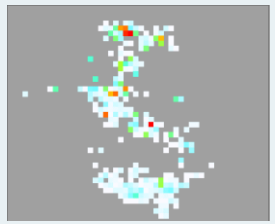
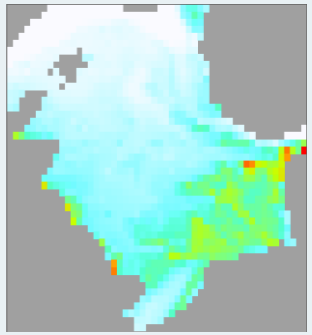


platforms

Modelled habitat capacity



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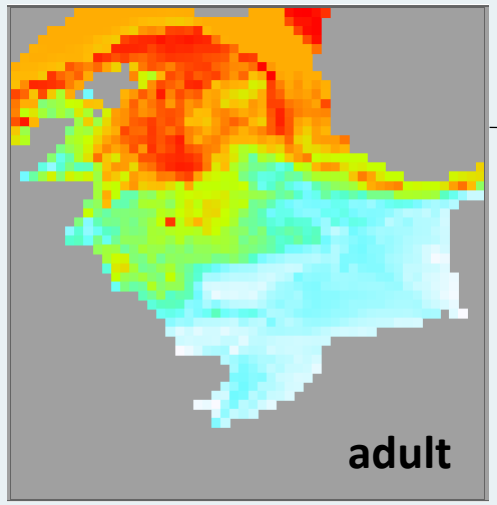
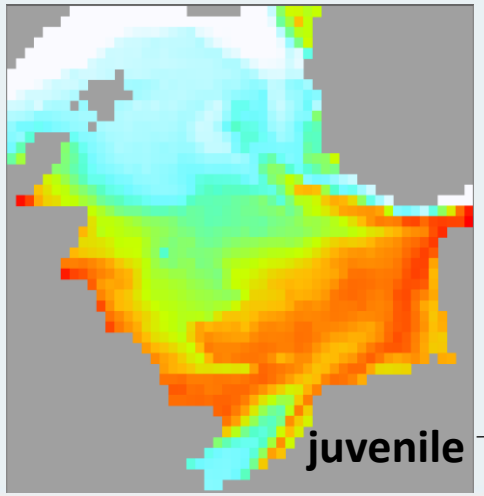
Cefas

From capacity to distribution

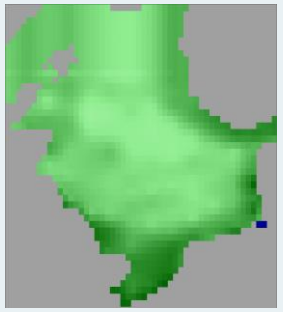
Modelled habitat capacity





Attraction toward prey groups

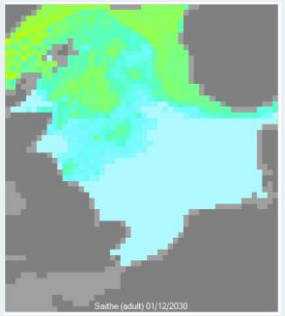
\+



e.g. plankton

Mortality by predators and dispersal away

\-



e.g. saithe

Removals through catch by fishing

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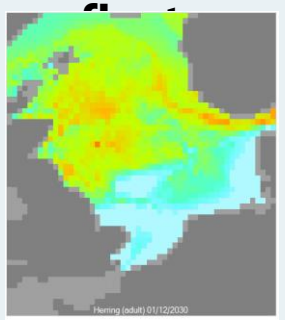
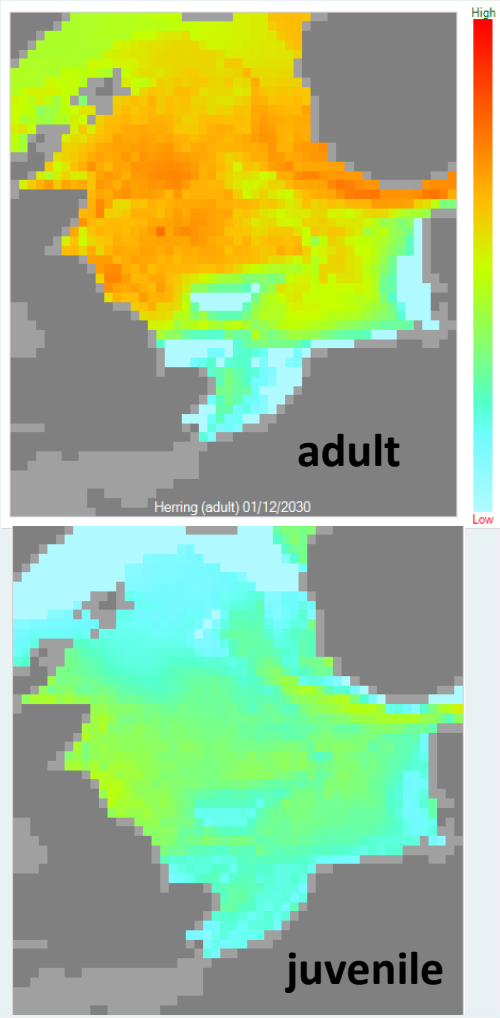


all fleets

Final distribution herring



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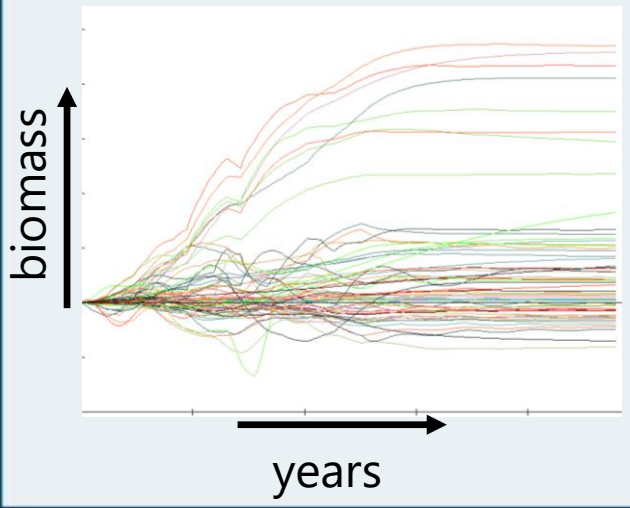
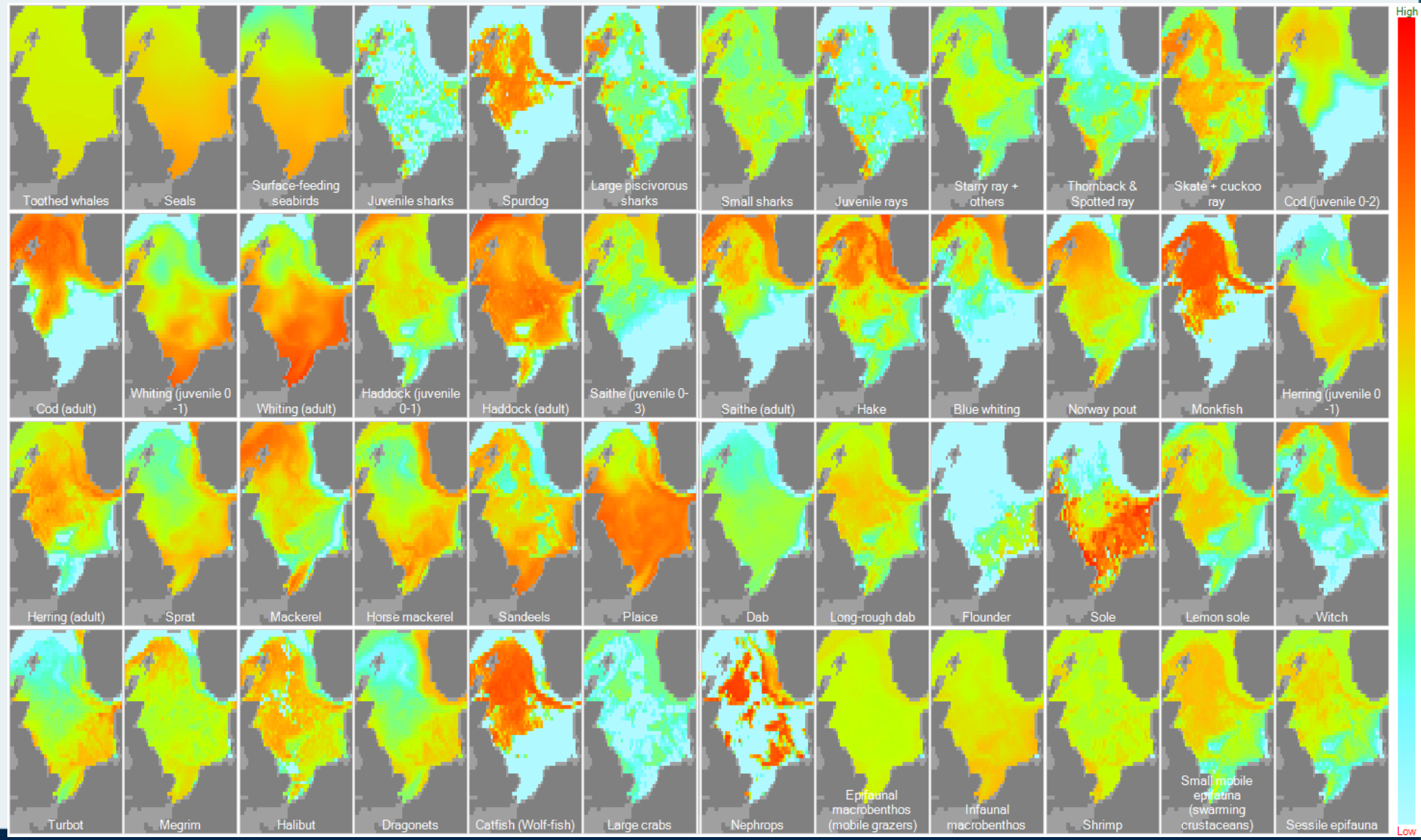
Cefas

Ecospace simulation

run to equilibrium





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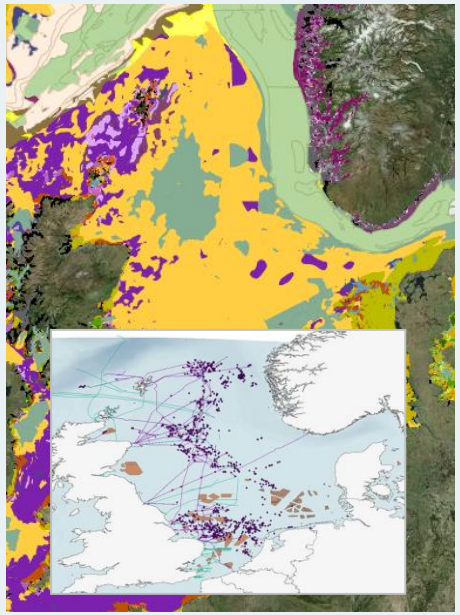
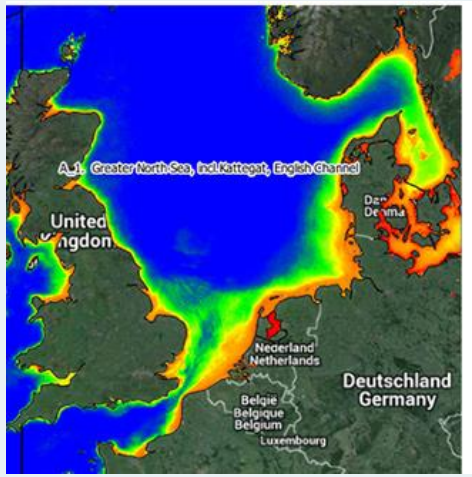
Cefas

COSM: objective 3

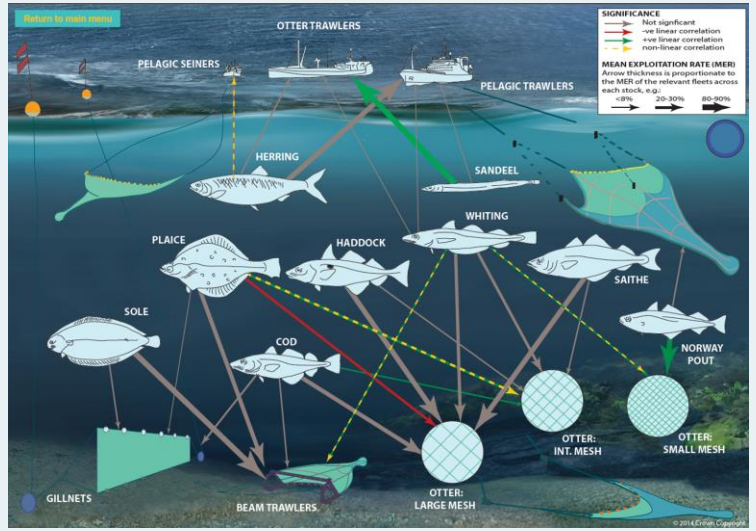
To explore the role of man-made structures on the food web relative to natural variation (temperature as a driver for production) and other pressures (fishing)



Habitats (natural vs artificial)



Natural variation



Fishing impacts

Ecospace Model Scenarios

S1: **No removal of structures (baseline)**

S2: **Complete removal of platforms and pipelines**

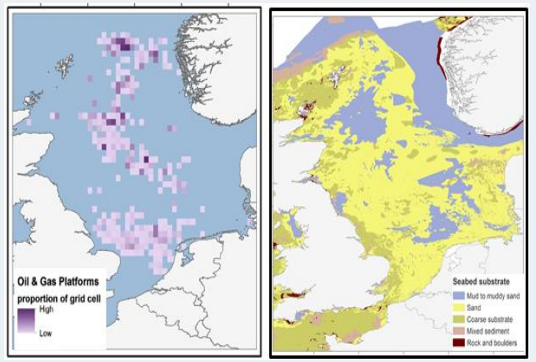
S3: Complete removal of platforms, pipelines + cables

S4: Complete removal of platforms, pipelines, cables, turbines + wrecks

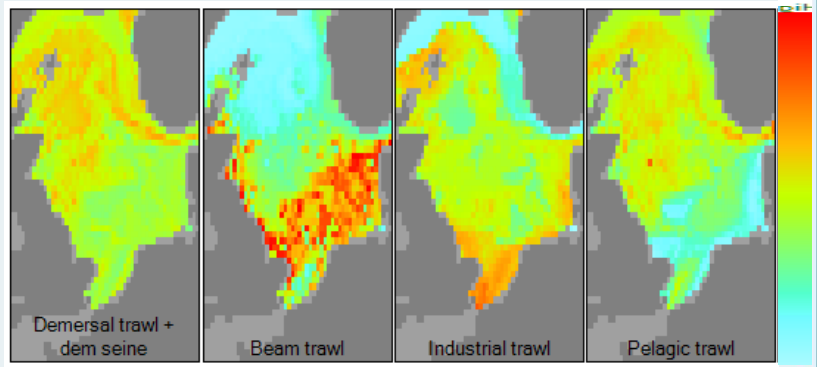
Hi F: **No removal of structures, increase in fishing effort**

Contrast change in biomass of groups near structures and in wider system

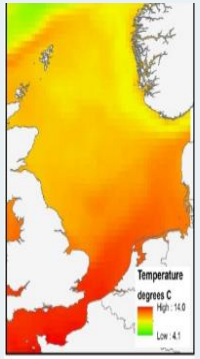
Replicate above scenarios with **climate variability** included



Habitats



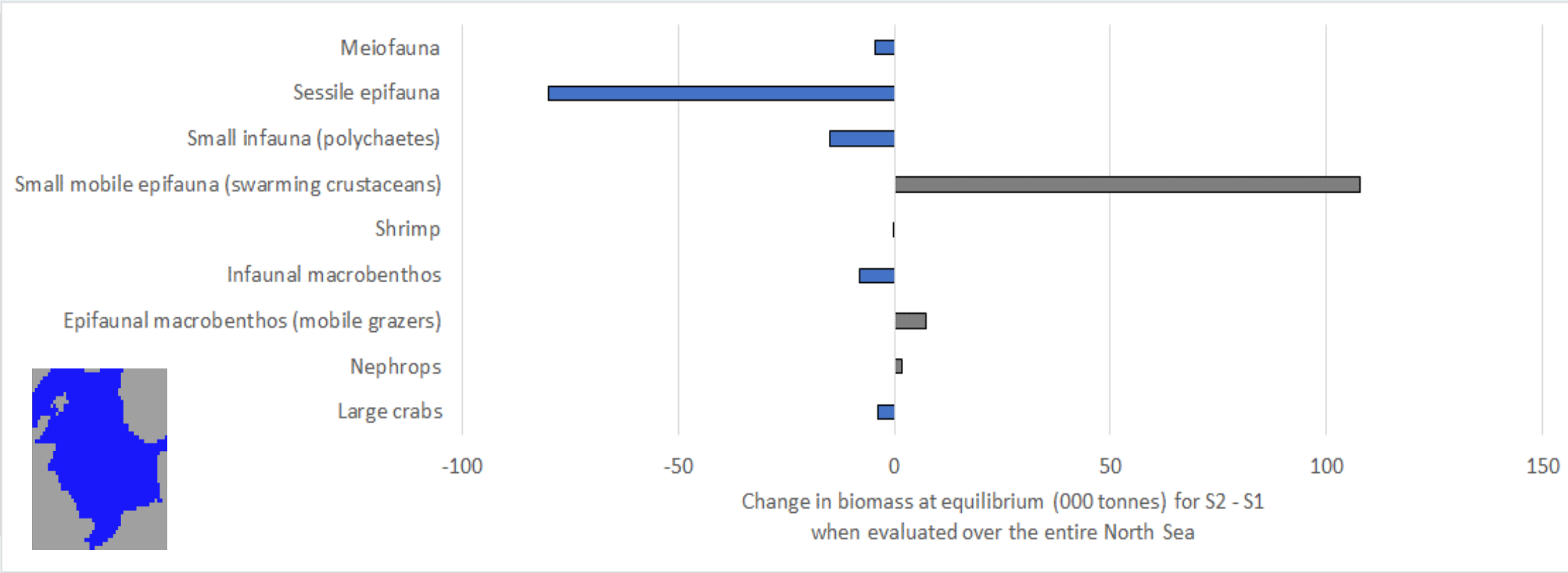
Fishing fleets



Temperature

Results

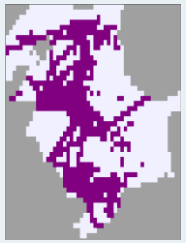
Change in biomass of selected benthic functional groups at equilibrium



Biomass (platforms and pipelines removed) *minus* Biomass (baseline)

Results *benthos*

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



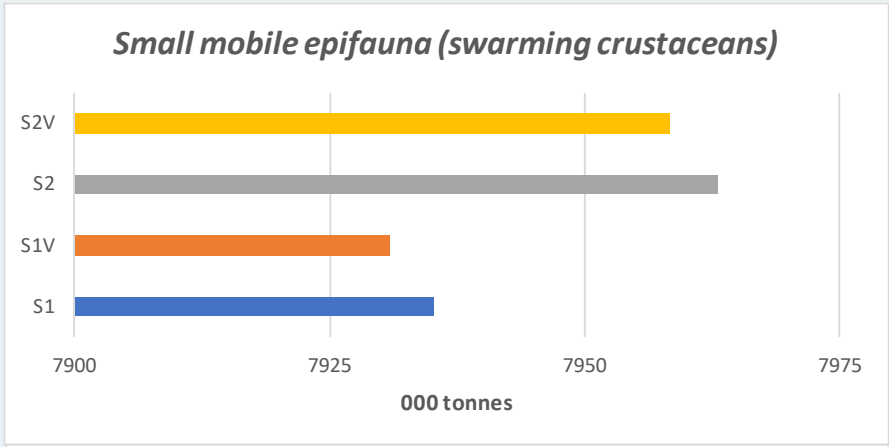
Scenarios

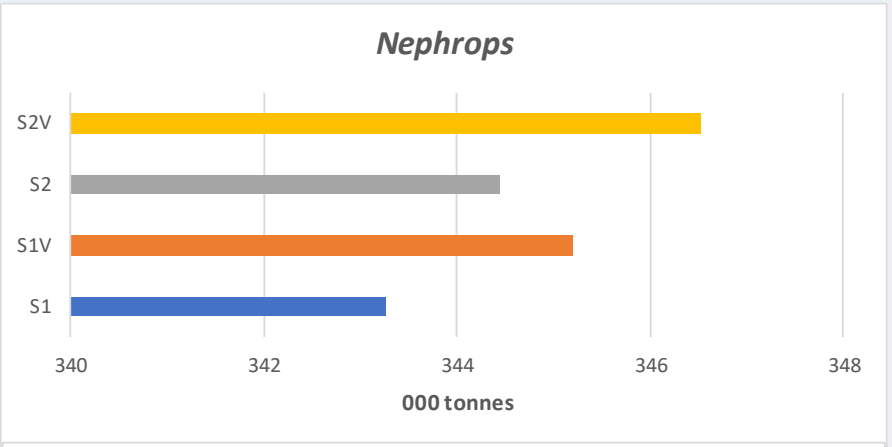
Baseline: S1

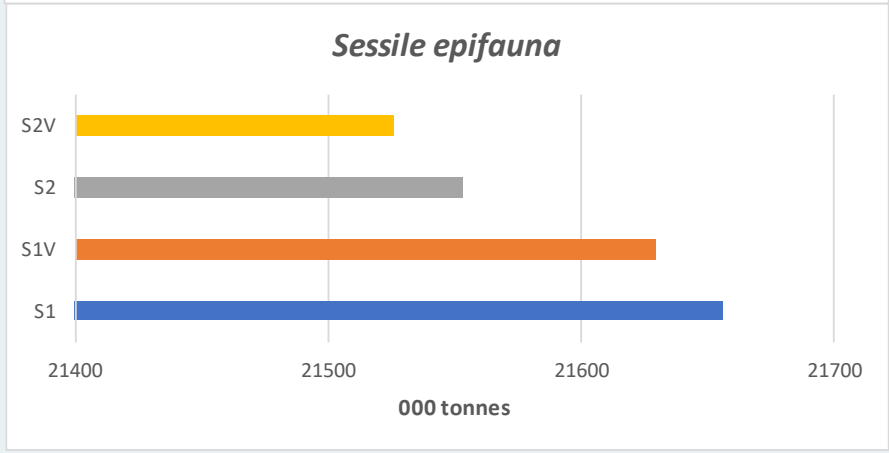
Platforms + pipelines removed: S2

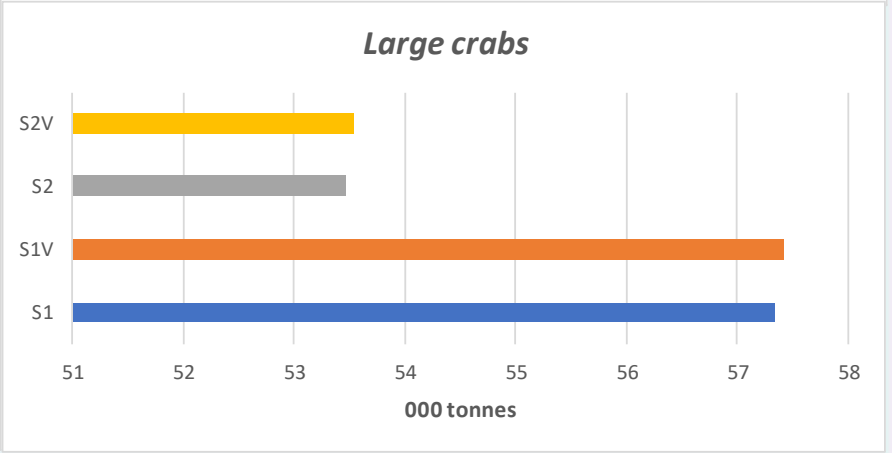
with and without natural variablility: +V

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









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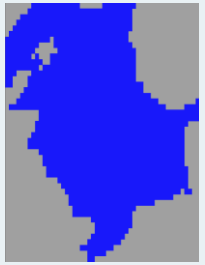
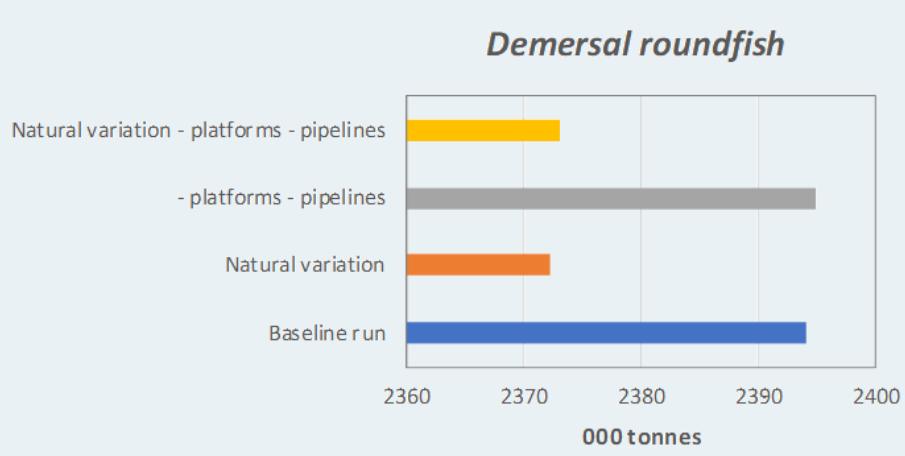
Cefas

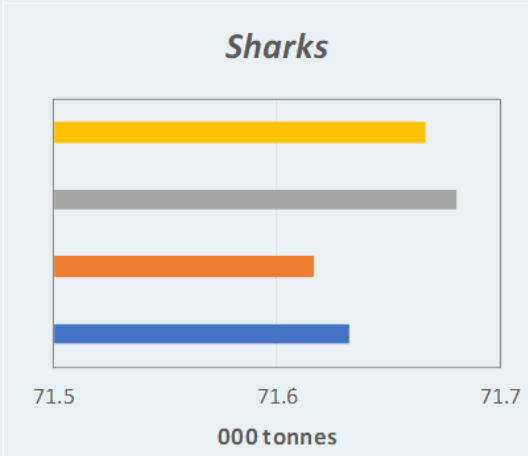
Results
fish

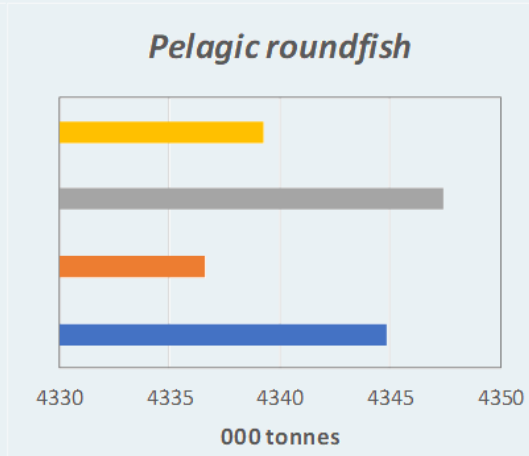
Estimates of biomass at equilibrium across the North Sea for selected management scenarios

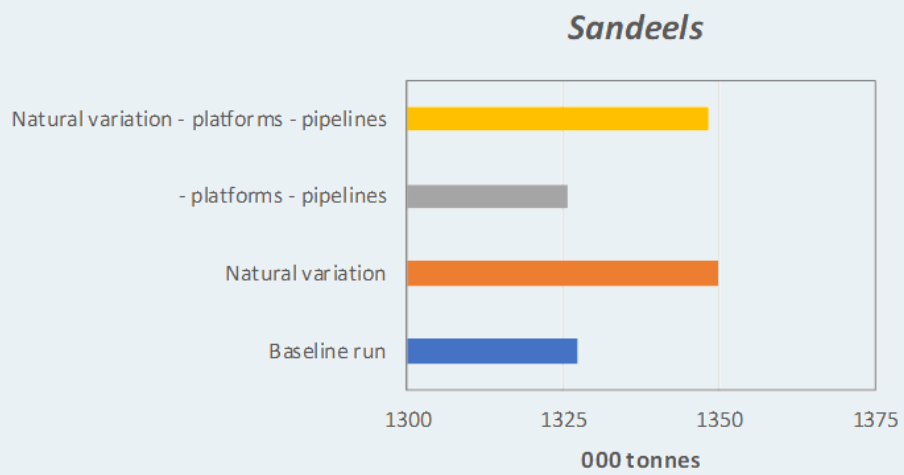


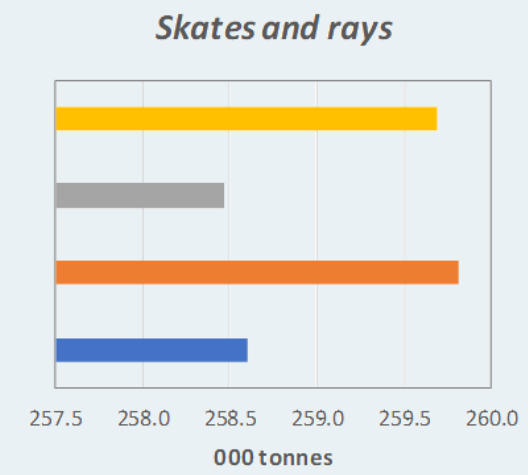
Change in biomass of selected fish groups

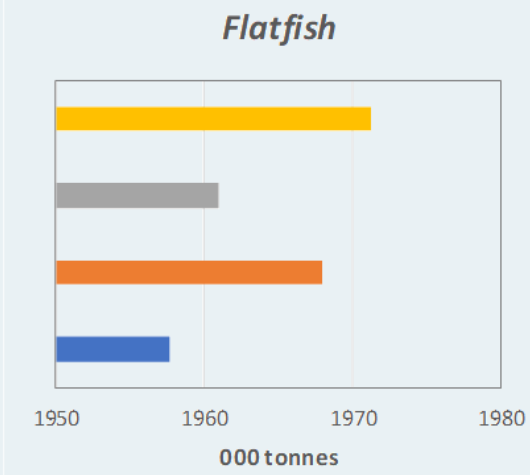












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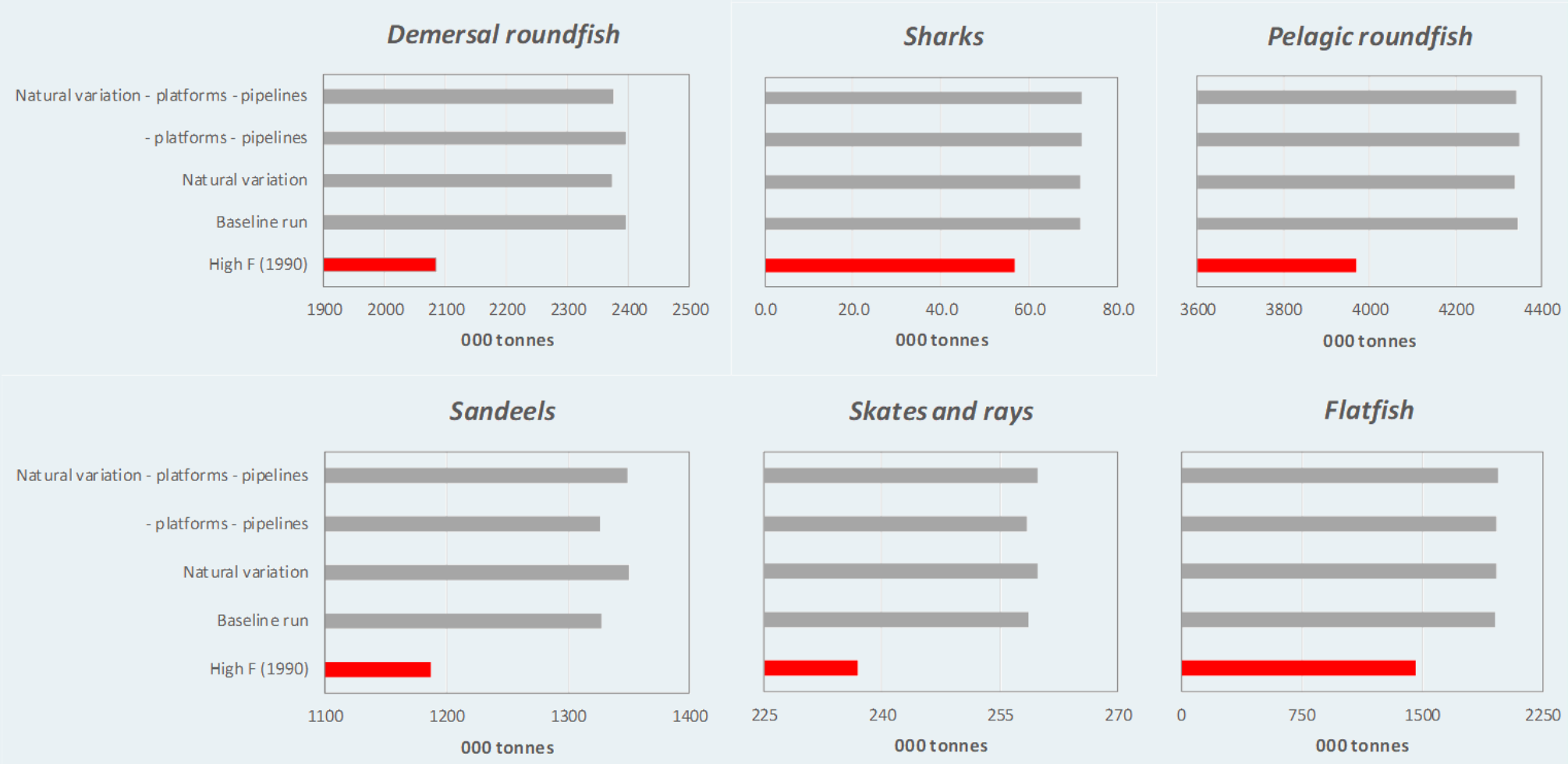
Results *fish*

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

Change in biomass of selected fish groups



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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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software development: Jeroen Steenbeek (EII), Christopher Lynam

model testing simulations: Christopher Lynam, Jeroen Steenbeek, Steven Mackinson

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