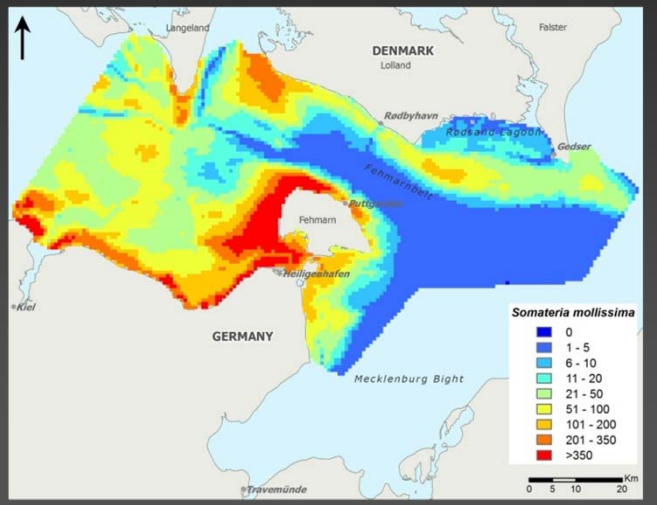
Useful tools for assessing conservation targets and impacts on marine habitats – examples of waterbird populations and marine infrastructures



Stefan Heinänen,
Ramūnas Žydelis, Henrik Skov
DHI

Femern Sund & Bælt

Aim & outline

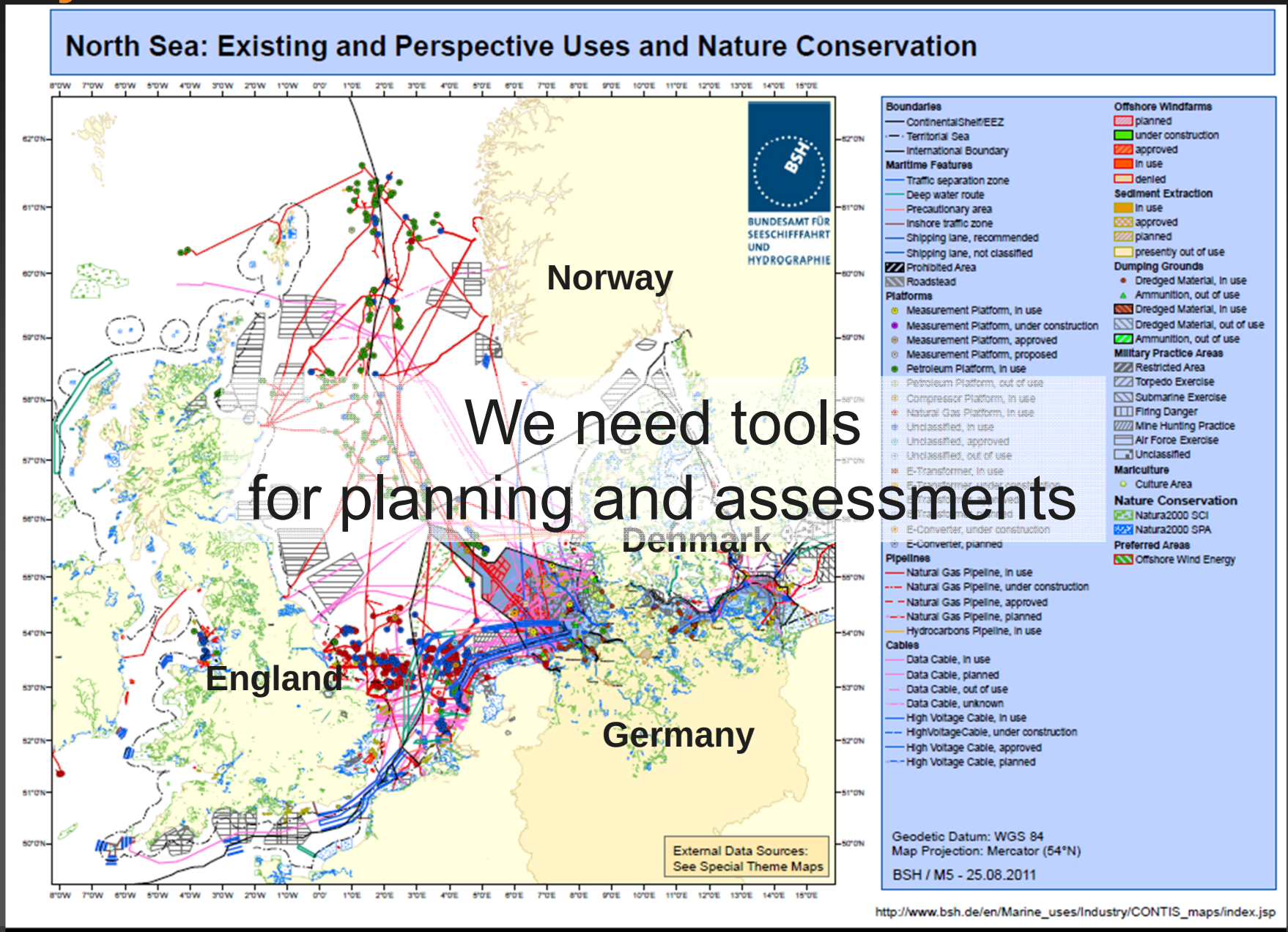
- To demonstrate a tool capable of describing and predicting the distribution of species…
- …and a tool for estimating the impact due to environmental changes

1) Species Distribution Modelling (SDM)
   - Distributions and numbers

2) Individual Based Modelling (IBM)
   - Impact due to changes in the environment

Examples from baseline investigations for the planned fixed link between Denmark and Germany, Fehmarn Belt

Why?


North Sea: Existing and Perspective Uses and Nature Conservation
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE
Norway
Denmark
England
Germany
We need tools
for planning and assessments
External Data Sources:
See Special Theme Maps
Boundaries
ContinentalShelf/EEZ
Territorial Sea
International Boundary
Maritime Features
Traffic separation zone
Deep water route
Precautionary area
Inshore traffic zone
Shipping lane, recommended
Shipping lane, not classified
Prohibited Area
Roadstead
Platforms
Measurement Platform, in use
Measurement Platform, under construction
Measurement Platform, approved
Measurement Platform, proposed
Petroleum Platform, in use
Pipelines
Natural Gas Pipeline, in use
Natural Gas Pipeline, under construction
Natural Gas Pipeline, approved
Natural Gas Pipeline, planned
Hydrocarbons Pipeline, in use
Cables
Data Cable, in use
Data Cable, planned
Data Cable, out of use
Data Cable, unknown
High Voltage Cable, in use
HighVoltageCable, under construction
High Voltage Cable, approved
High Voltage Cable, planned
Offshore Windfarms
planned
under construction
approved
in use
denied
Sediment Extraction
in use
approved
planned
presently out of use
Dumping Grounds
Dredged Material, in use
Ammunition, out of use
Dredged Material, in use
Dredged Material, out of use
Ammunition, out of use
Military Practice Areas
Restricted Area
Torpedo Exercise
Submarine Exercise
Firing Danger
Mine Hunting Practice
Air Force Exercise
Unclassified
Mariculture
Culture Area
Nature Conservation
Natura2000 SCI
Natura2000 SPA
Preferred Areas
Offshore Wind Energy
Geodetic Datum: WGS 84
Map Projection: Mercator (54°N)
BSH / M5 - 25.08.2011
http://www.bsh.de/en/Marine_uses/Industry/CONTIS_maps/index.jsp

Part 1 - Species Distribution Modelling

- **Where are the birds (species)?**
- **Why are they there?**
- **How many are they?**

- SDMs statistically relate **species observations** to **environmental variables**
- Widely used in terrestrial settings
- A large number of algorithms available
- Regression methods commonly used
- Can be used for different types of responses
  - Presence only
  - Presence/absence
  - Abundance
  - Densities
  - Cover

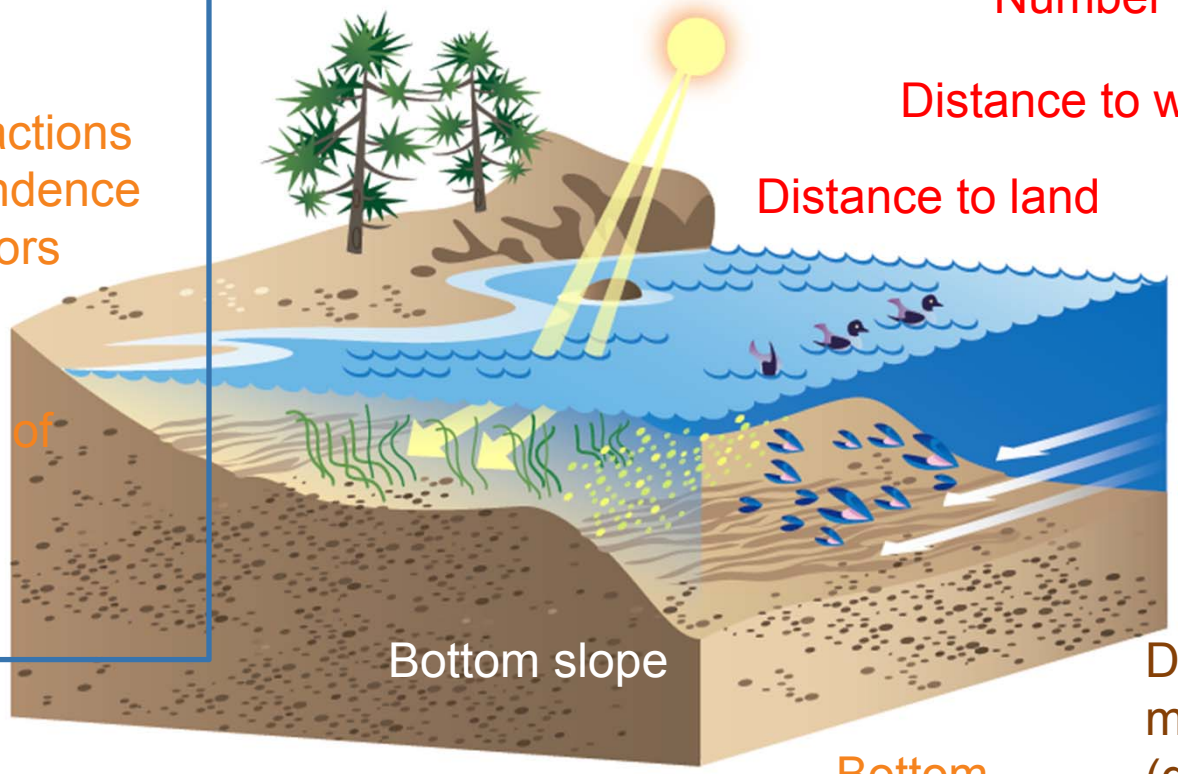
SDMs – Species data

- Aerial surveys
  - Presence/absence
  - Density
  - Abundance
- Ship surveys
  - Presence/absence
  - Density
  - Abundance
- Telemetry data
  - Presence only

SDMs – Environmental data

Site fidelity
Species interactions
Density dependence
Unknown factors

Large amount of unexplained variance



Number of ships

Distance to wind farms

Distance to land

Depth

Currents (dynamic)

Density of mussels (dynamic)

Bottom substrates

Bottom slope

Geographic predictors
X,Y coordinates

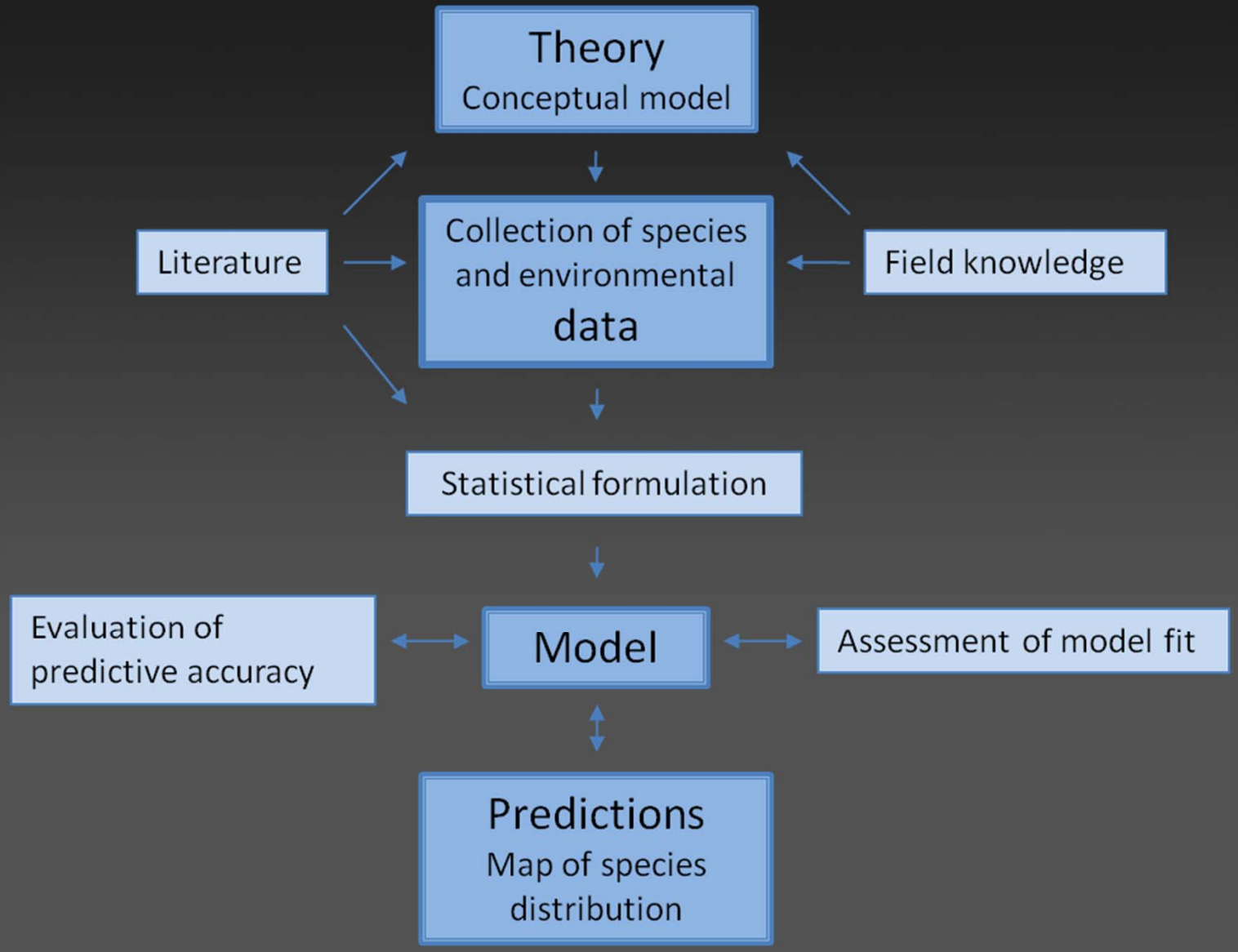
BUT....

- Nonlinear relationship
- Non-normal distribution
- Zero inflation
- Spatial autocorrelation in model residuals
- Correlation among predictors
- Unoccupied suitable samples
- Occupied unsuitable samples

- Important to evaluate the model
  - Model fit
  - Predictive accuracy
  - Interpretability

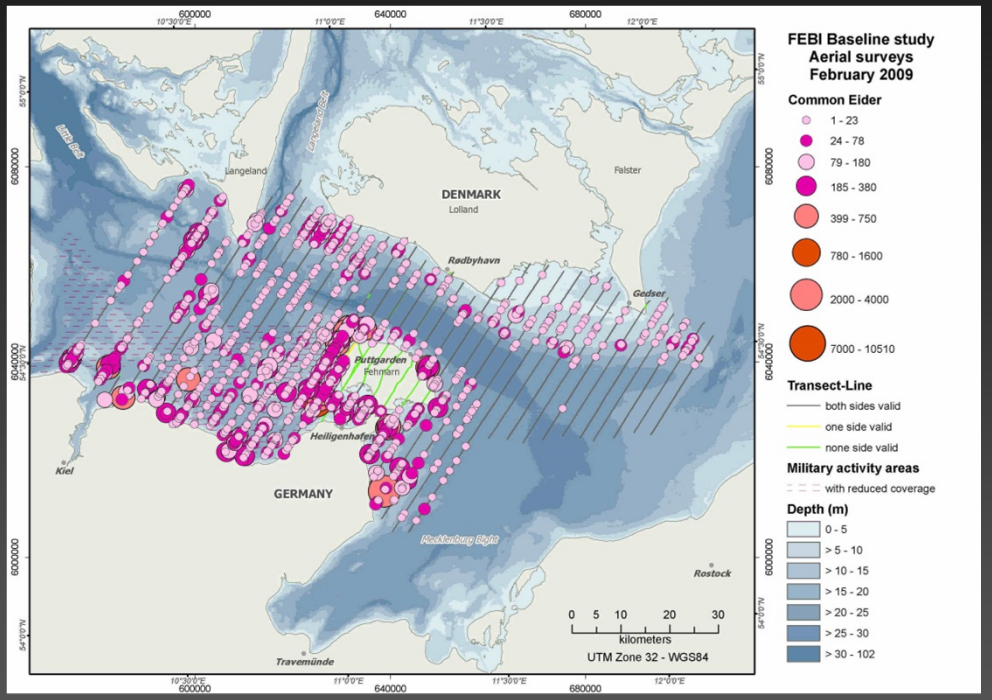
- ➢ By using Generalised Additive Models (GAMs)
- ➢ By using a two-step model
- ➢ Checking...
- ➢ Aggregating data into larger cells

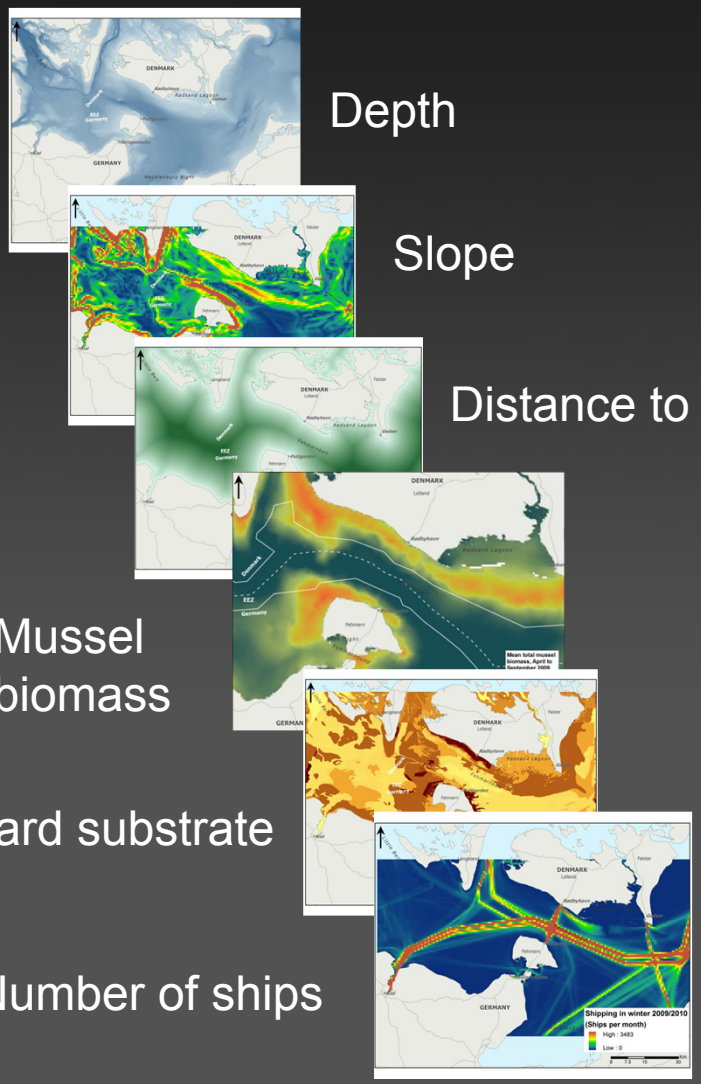
SDM framework



Example – Eiders in Fehmarn belt

Species data = Eider densities





Depth

Slope

Distance to land

Mussel biomass

Hard substrate

Number of ships

X,Y coordinates

Two-step Genaralised Additive Model

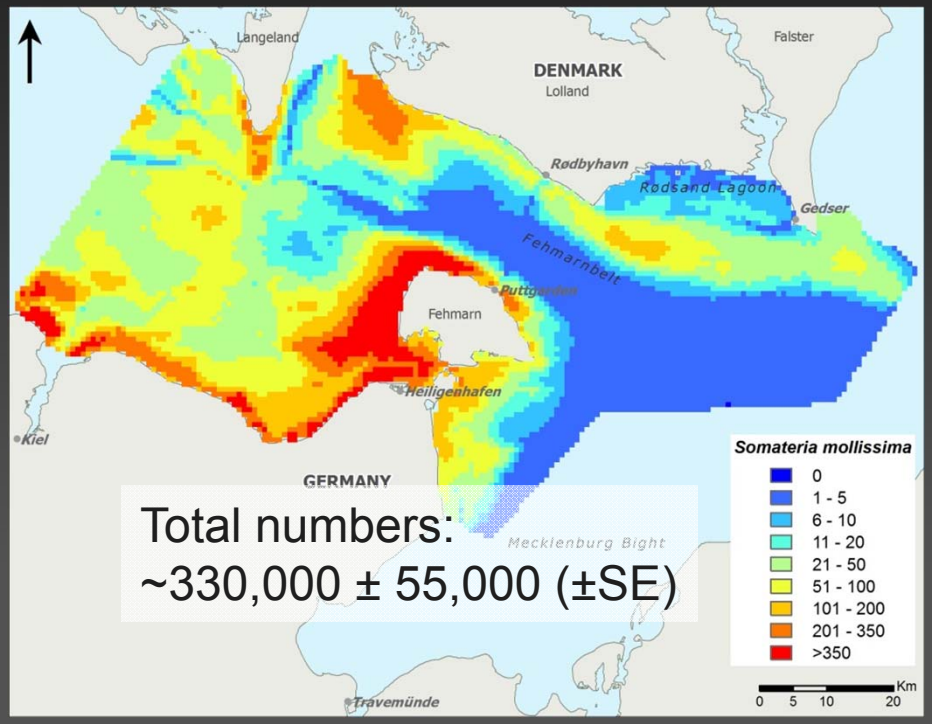
1) Binomial (presence/absence model)
2) Positive part (gamma with log link)

→ Predict and map

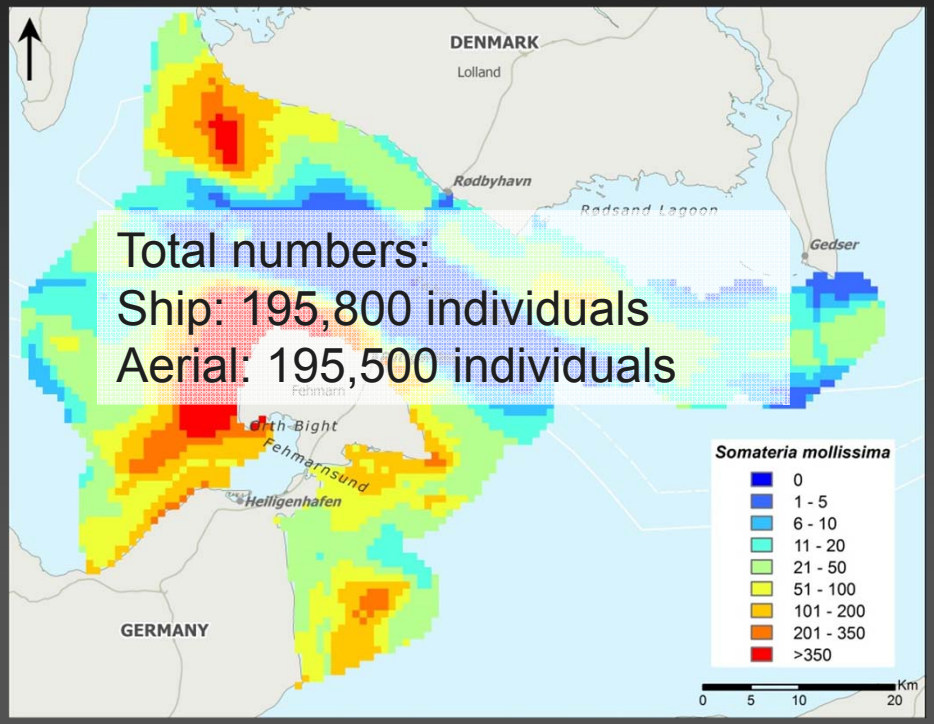
Results – Eiders in Fehmarn Belt

November 2009 – February 2010

Predictions based on aerial surveys

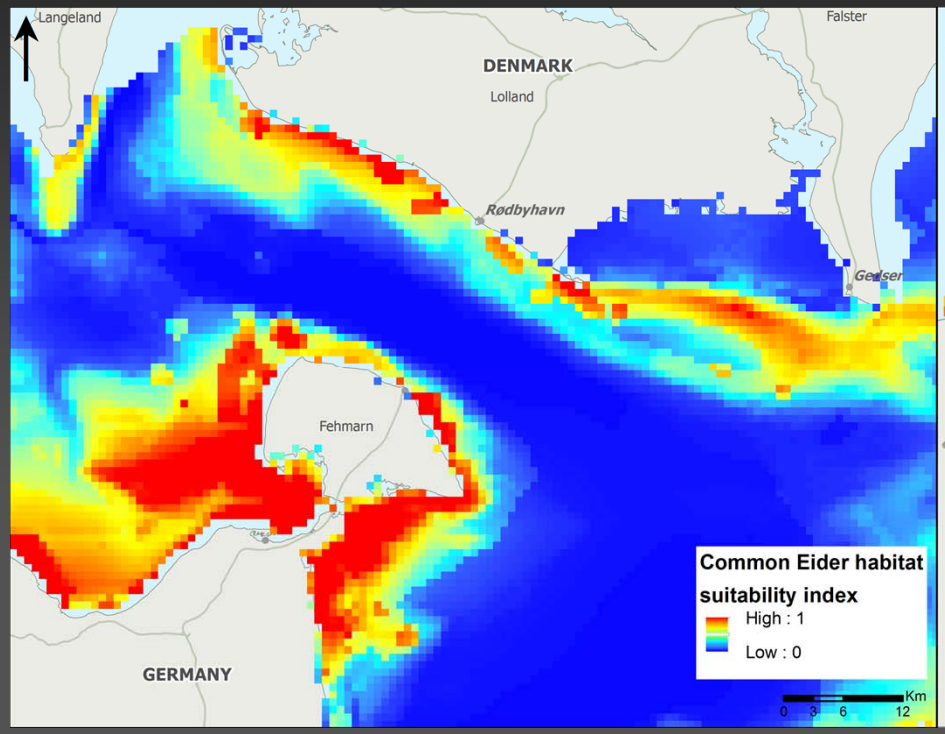


Predictions based on ship surveys

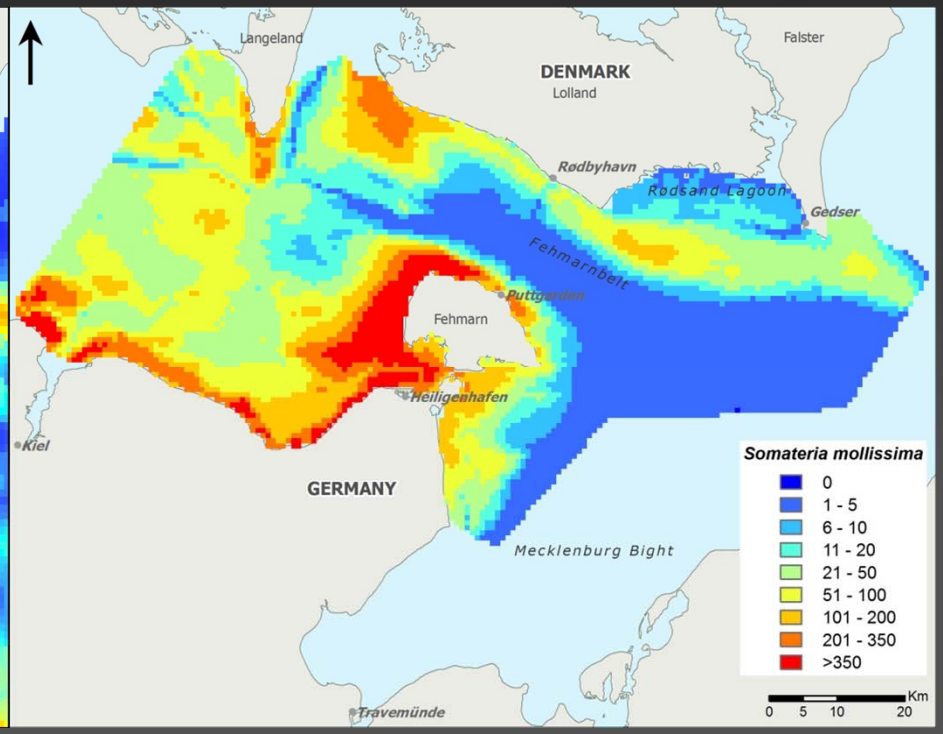


Results – Eiders in Fehmarn Belt

Probability model based on telemetry data



Density model based on survey data



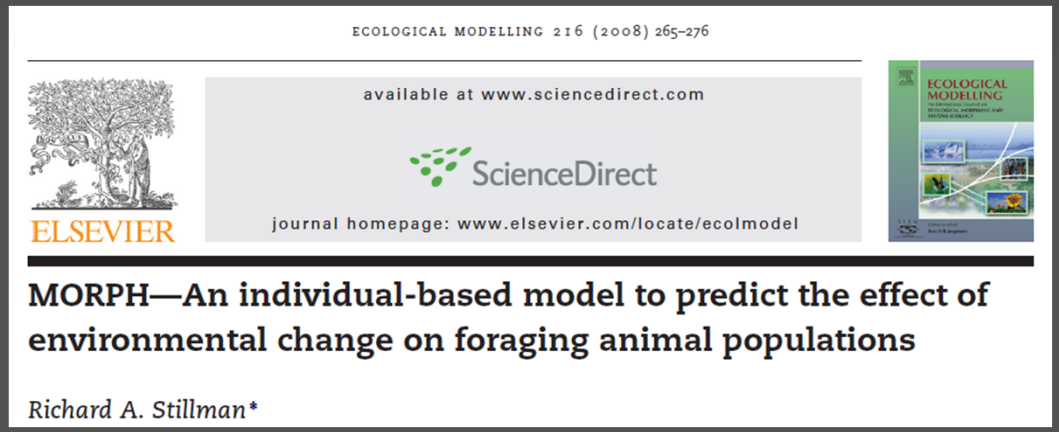
Conclusions SDMs

- We are able to make reasonable predictions and map the distribution patterns
- We are able to estimate reasonable numbers
- The different models produces comparable results
- The models will never be better than the input data
  - We need to carefully assess the predictions
  - **THE SDMs CAN BE VERY USEFUL TOOLS!**

Part 2 - Individual Based Models

- **What is the impact on a bird population if...?**
- **Different scenarios depending on different expected environmental changes**

- An IBM is a virtual ecosystem
- Can be used to predict the effect of environmental change
- Different modelling platforms available



ECOLOGICAL MODELLING 216 (2008) 265–276

available at www.sciencedirect.com

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ELSEVIER

MORPH—An individual-based model to predict the effect of environmental change on foraging animal populations

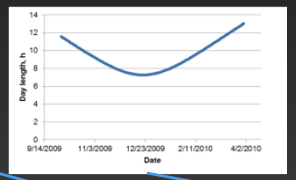
*Richard A. Stillman**

Building the IBM using Morph

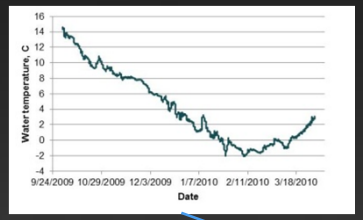
Study system

Study grid

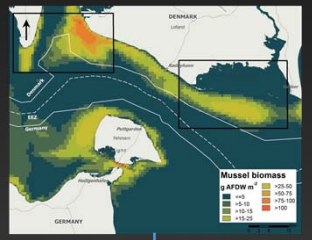
Day length

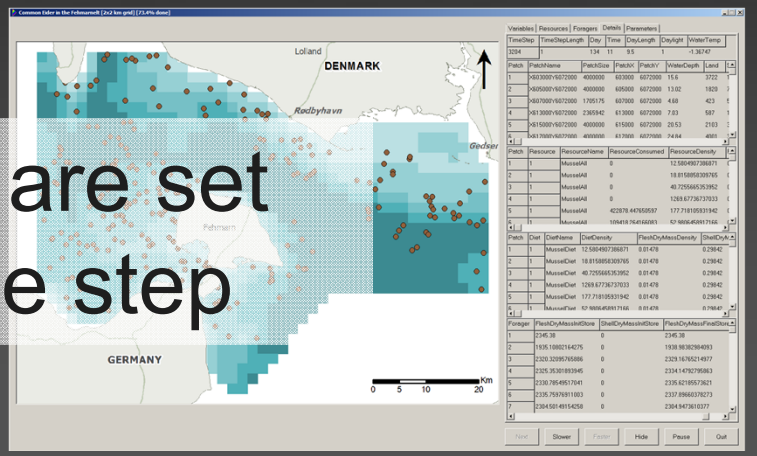


Water temperature

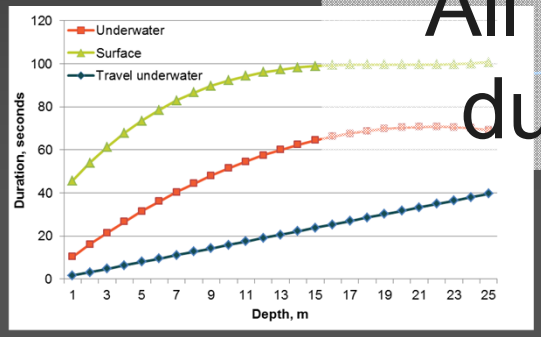


Mussel biomass



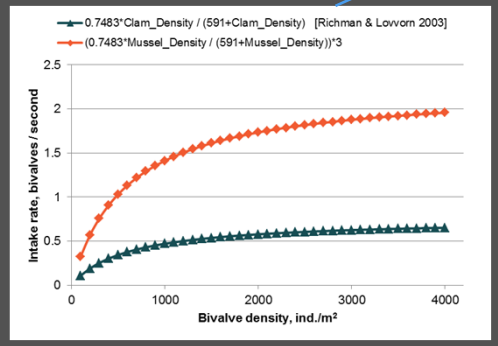


Foraging behaviour



All these events are set during each time step

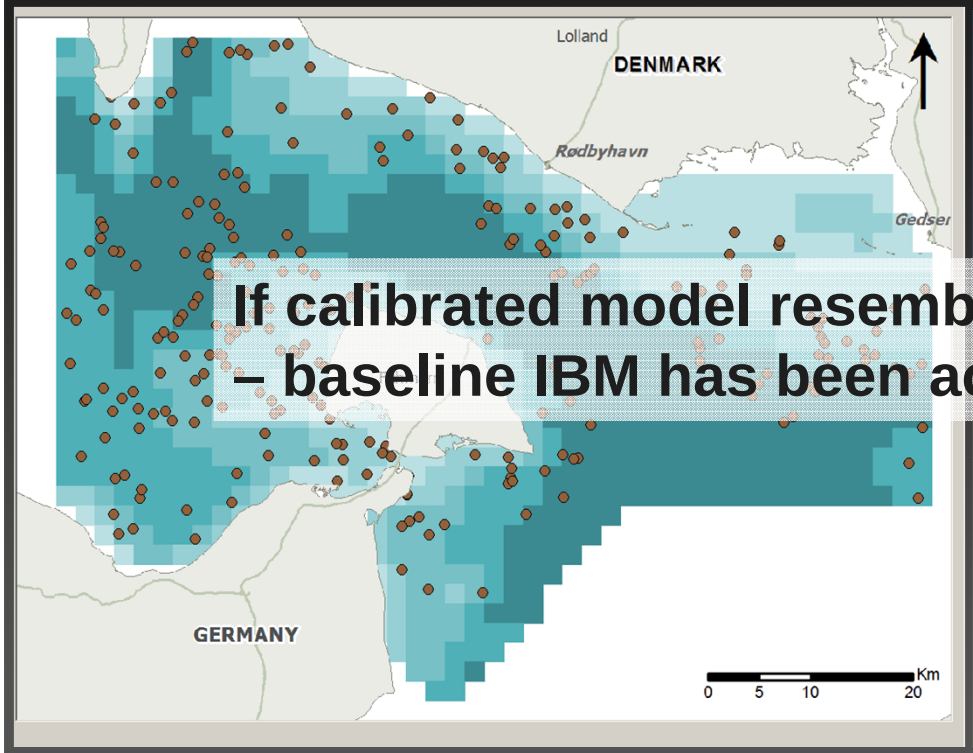
Intake rate of food depending on food densities

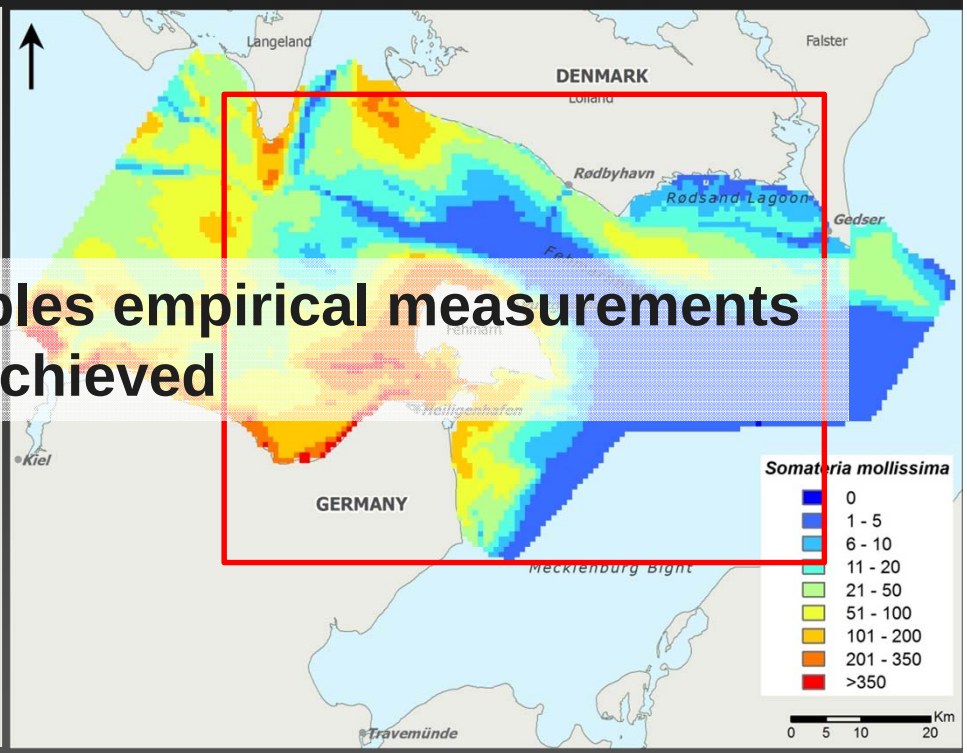


Forager variables
Forager = Common Eider

Max density = 5,000 birds / km²
Initial body mass = 2,135 g
Target body mass = 2,371 g
Min body mass = 1,476 g

IBM results





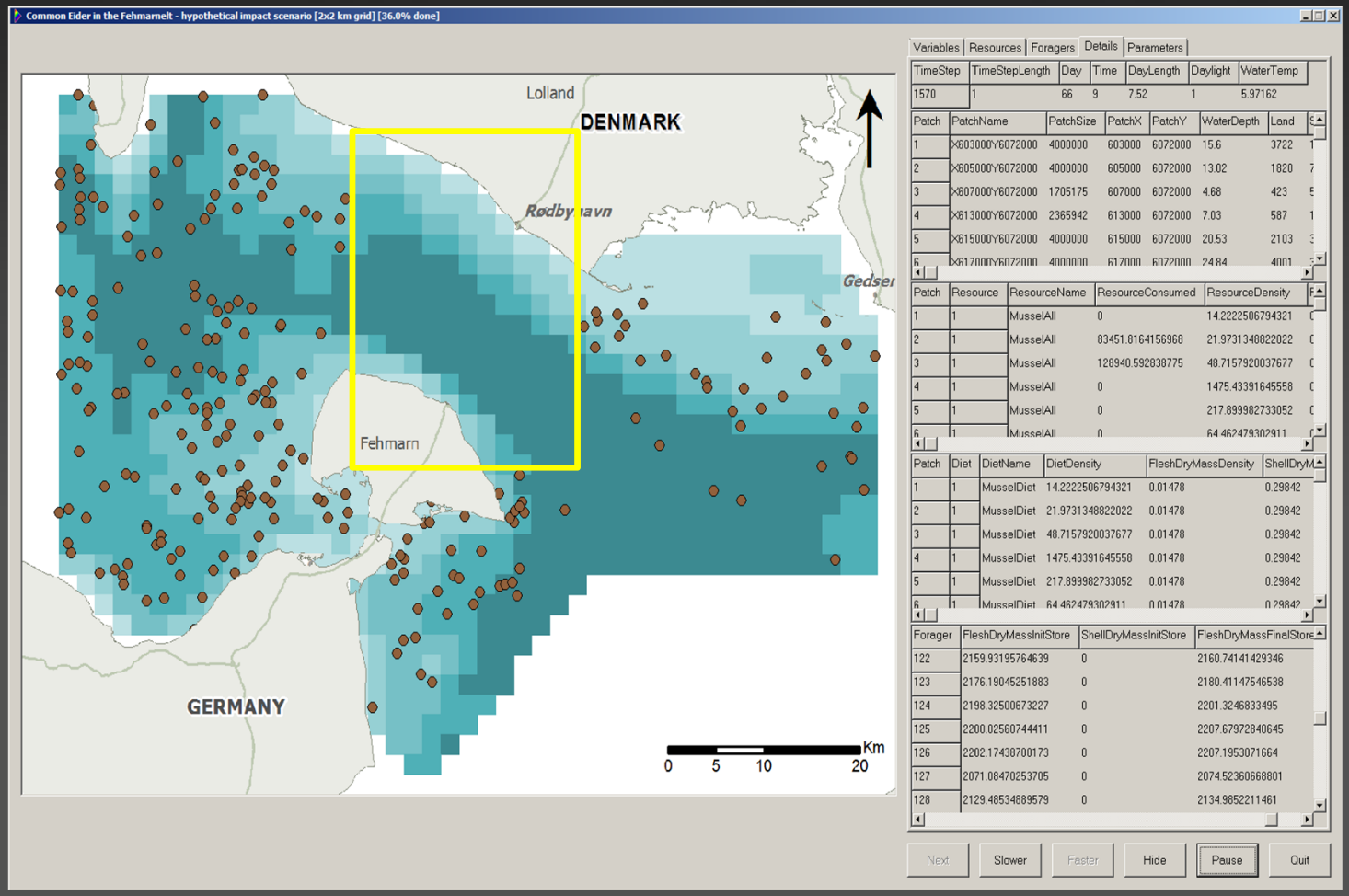
If calibrated model resembles empirical measurements – baseline IBM has been achieved

Multiple model outputs in addition to distribution

- Survival of model birds
- Bird body mass
- Time spent foraging
- Food intake

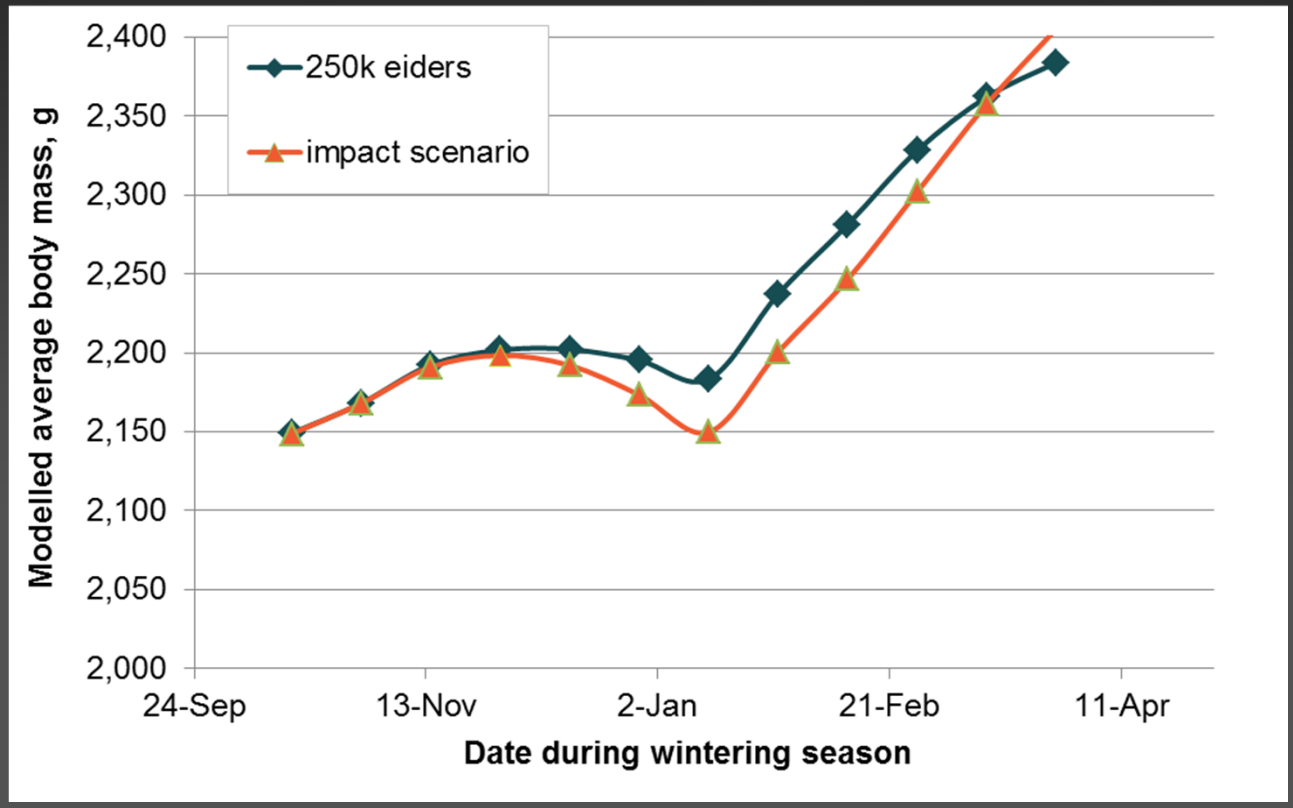
Application: assessment of impact

Running hypothetical impact scenario (food = 0 in the ‘impact’ area)



Impact

Results of impact scenario: all birds survived, but maintained lower body mass during most of the wintering period.



Conclusions IBMs

- Individual based modelling can be a useful tool when assessing impacts of environmental changes
- Carrying capacity can be estimated by using IBMs
- IBM parameterisation is challenging and requires careful considerations about the interactions between birds and their environment

Thank You!

Thanks to our colleagues in the Fehmarn Belt project
BioConsult, Biola and **University of Copenhagen**