Quantifying sensitivity: a framework to map relative risk to seabirds from future offshore wind energy developments in Danish marine waters

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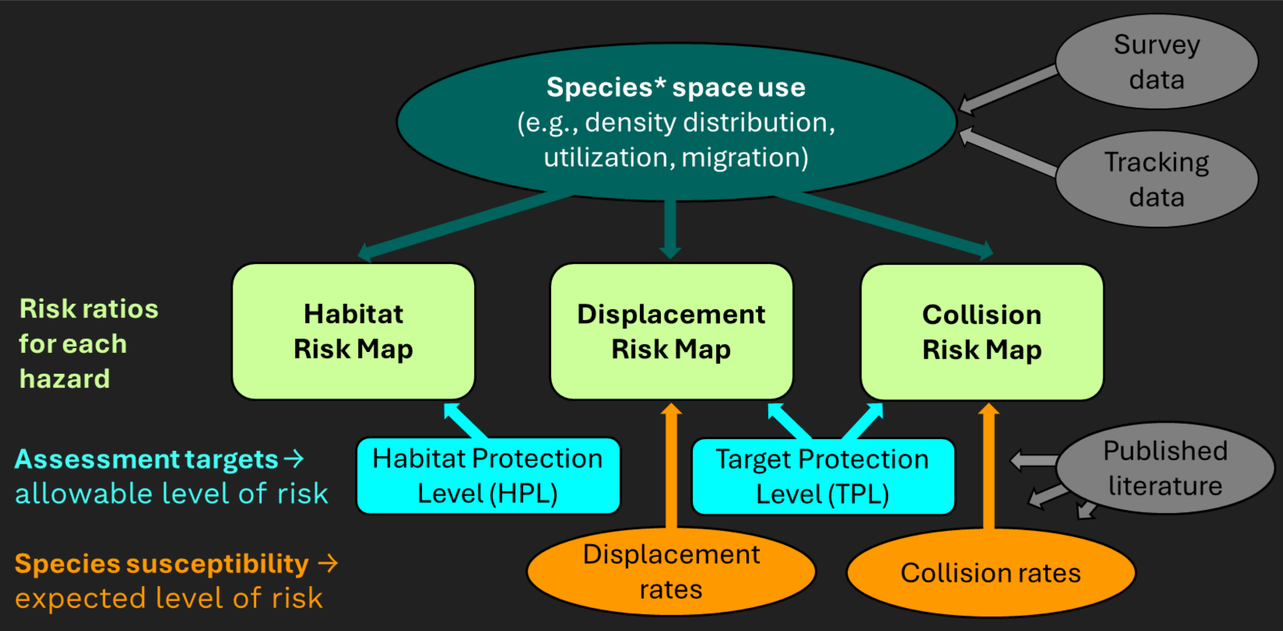
Conceptual approach

- **Risk** = likelihood & consequence of unwanted outcomes for species
- **Sensitivity map** = spatial ranking of areas by species risks
- **Relative risk** = risks relative to assessment targets
- **Hazard** = source of risk. We considered:
  1) Overlap with core habitat
  2) Displacement
  3) Collision

$$\text{RISK RATIO} = \frac{\text{Expected level of risk}}{\text{Allowable level of risk}}$$

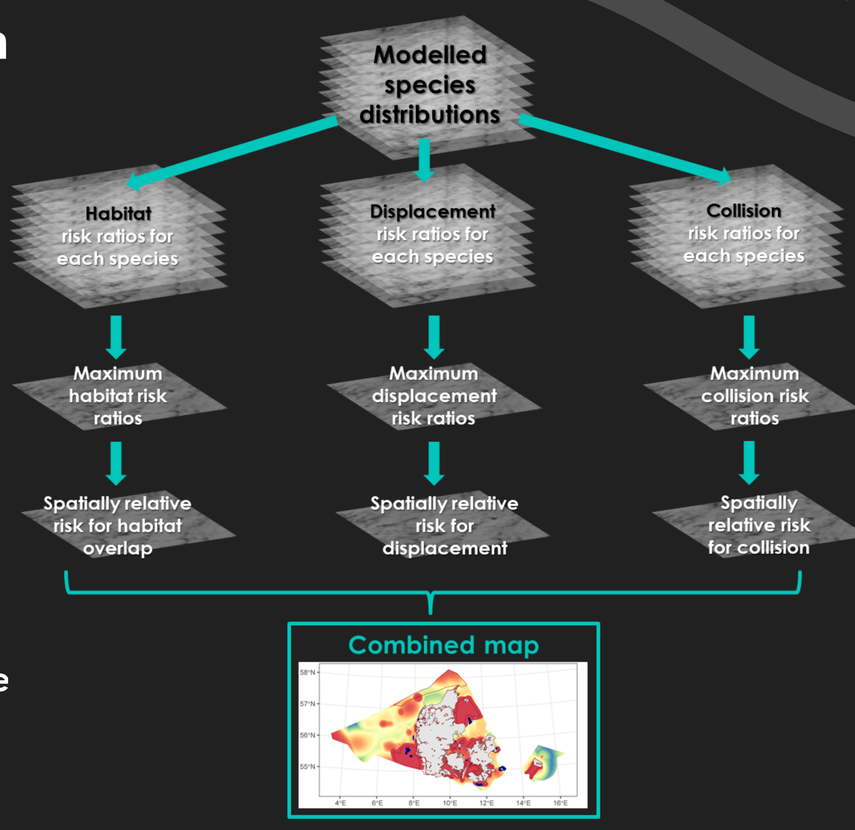


** Species or species groups comprising ecologically similar species. We grouped together divers, alcids (razorbill & guillemot), grebes (red-necked & great crested), grey gulls (herring & common), and terns (common, Sandwich, Arctic).*

The algorithm

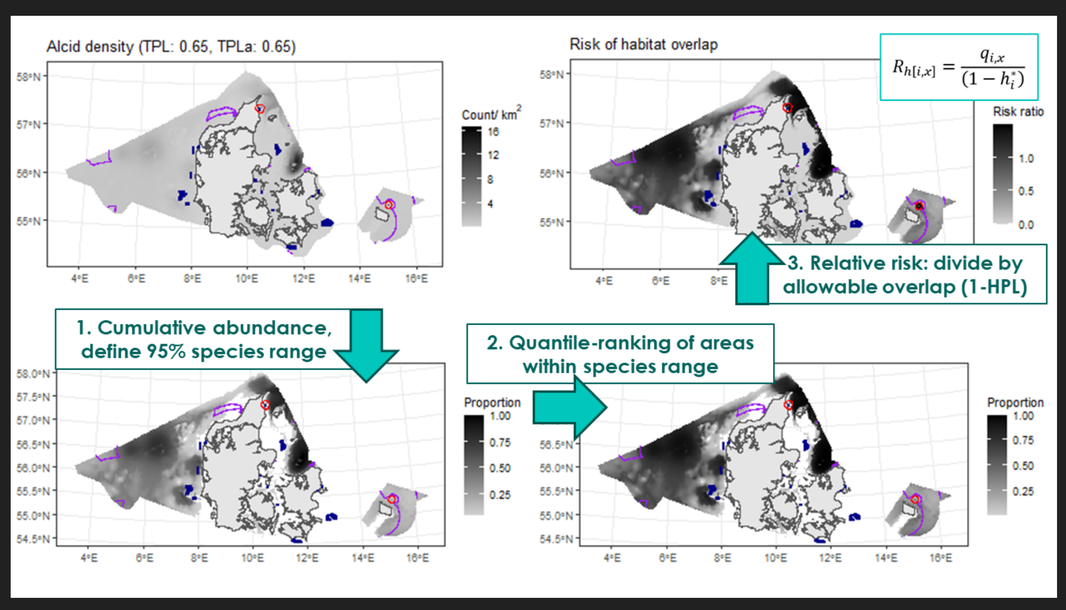
Four main steps:

1. **Species risk relative to assessment targets**
2. **Maximum species risk at each map location**
3. **Rank areas by maximum species risk**
4. **Highest-ranking areas across the three hazards**



Calculation of relative species risks

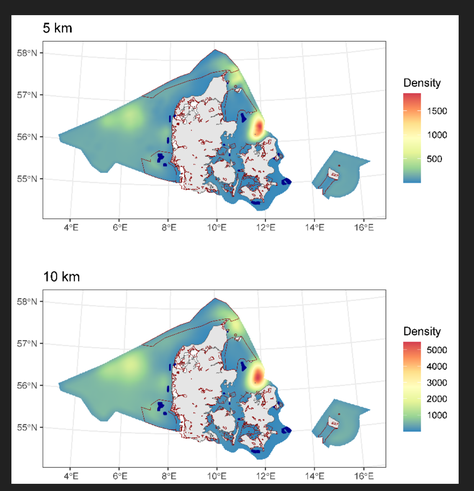
$$\text{Habitat risk ratio} = \frac{\textit{expected overlap with core areas}_{\textit{for each grid cell,species}}}{1 - \textit{habitat protection level}}$$



$$\text{Displacement risk} = \frac{\textit{expected number of birds at risk}_{\textit{for each grid cell,species}}}{1 - \textit{target protection level}_{\textit{outside designated SPAs}}}$$

Displacement rate & extent

- Species-specific rates (/km²) derived from a literature review
- To represent expected number of displaced birds in each 1x1 km grid cell, we accounted for bird density in adjacent grid neighbourhoods
  - → Larger displacement ranges lead to smoother spatial patterns



$$\text{Collision risk} = \frac{\textit{expected number of birds at risk}_{\textit{for each grid cell,species}}}{1 - \textit{target protection level}_{\textit{outside designated SPAs}}}$$

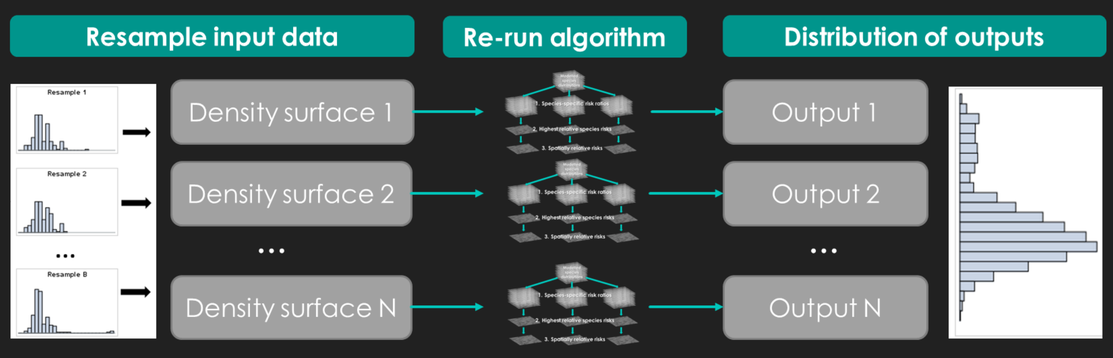
Proxy collision rates:

- Derived from collision risk modelling with species-specific input parameters (avoidance rates, body size, flight speed), holding wind farm parameters constant

stochLAB

Bootstrapping uncertainty

- Resample inputs to generate a distribution of outputs: summarize 95% percentiles and coefficient of variation (CV) to represent uncertainty



- Current implementation accounts for uncertainty in underlying density surfaces; next version to incorporate uncertainty in all inputs

Ongoing & future work

- Cumulative risk over multiple planning areas
- Shifting baselines: time-weighting historical survey data (25 yrs)
- Incorporating seasonal differences in distribution/usage
- Incorporating tracking data
  - Flight height distributions to inform CRM
  - Usage & passage rates (e.g., migration intensity)
- Interactive web-based tool (Shiny)

Report available online https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Tekniske_rapporter_300-349/TR331.pdf

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