Fin whale (*Balaenoptera physalus*) distribution modelling in the Nordic Seas & adjacent waters

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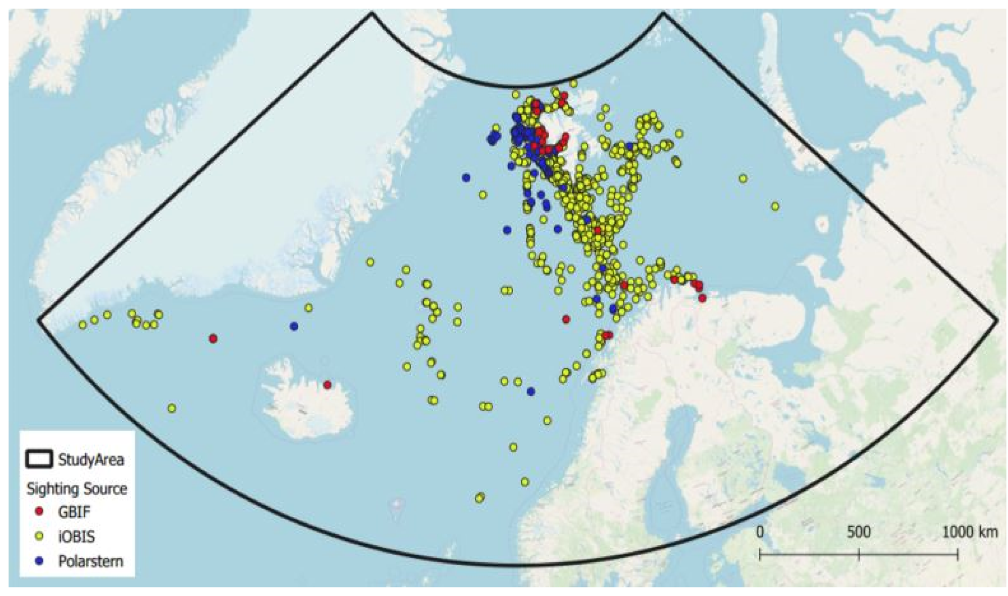
Introduction

Understanding cetacean distribution is essential to interpret impacts of environmental change on species ecology and ecosystem functioning. Studies on baleen whale distribution are comparably rare in polar regions, mainly due to financial or logistic constraints. Here we use species distribution models (SDMs) to predict habitat suitability for fin whales (*Balaenoptera physalus*) in Arctic waters. SDMs are helpful tools linking species occurrences to environmental variables (EVs) to predict potential distributions. The aim of this study was to identify suitable habitats for fin whales in the Nordic Seas and underlying EVs, as potential drivers of the species' distribution, during summer.

Material and Methods

The study area encompasses the Nordic Seas, with a spatial extent from N60°-N81° and W45°-E55°.



Observations

- 2004 to 2018 (May to September)
- 10 RV Polarstern cruises in the Arctic Ocean
- Open-source data (iOBIS, GBIF)

→ 1229 sightings (746 unique, 10 x 10 km grid cells)

Environmental Variables

- Selected based on ecological relevance
- 24 initial EVs, 14 final: e.g. aspect, bathymetry, chlorophyll a, slope and velocity

Software / Approach

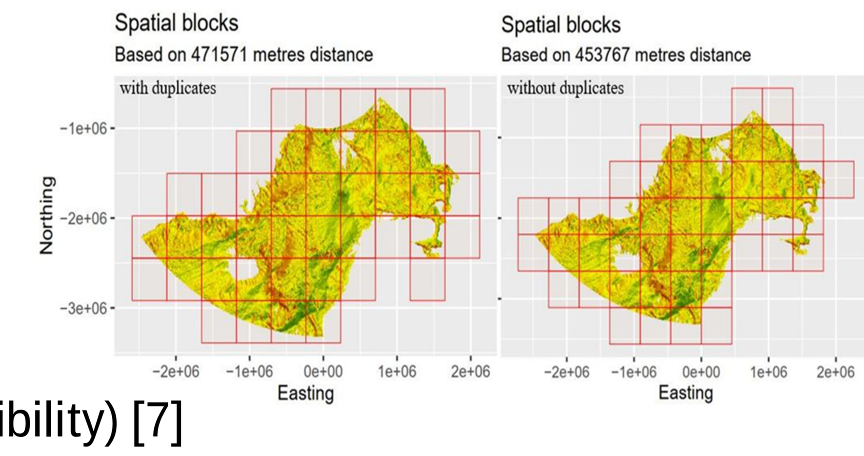
MaxEnt v3.4.1 [1,2], R-3.6.1. [6]

R-packages "ENMeval" [4], "blockCV" [5]

→ 4 spatially cross-validated folds, 1 full model

2 modelling approaches, to account for sampling bias:

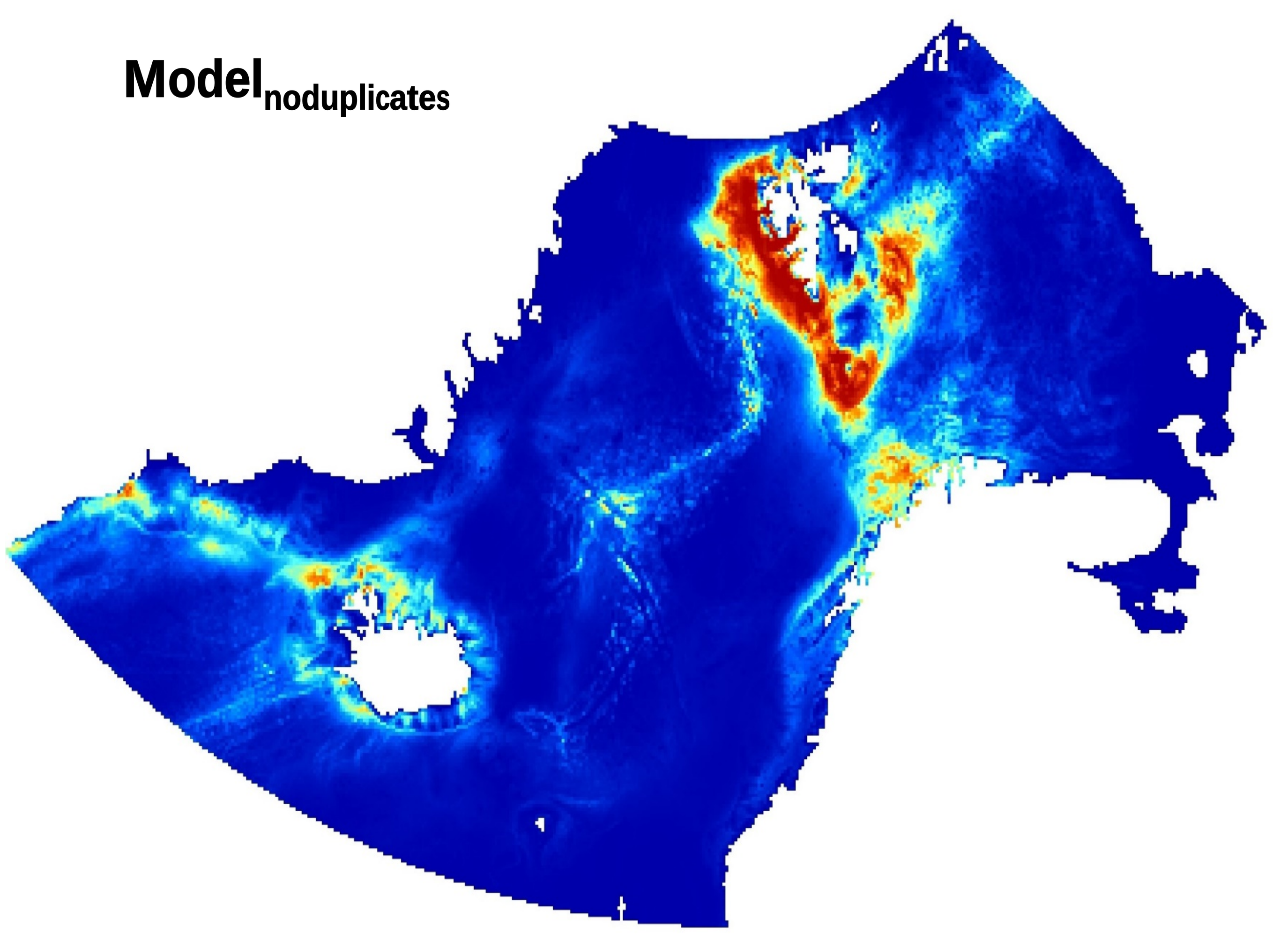
- spatial thinning (removed duplicates)
- setting EV distance to shore to 0 during prediction (accessibility) [7]

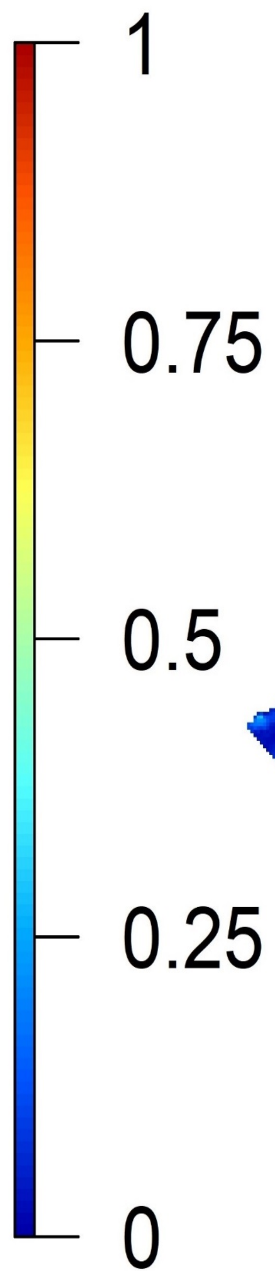


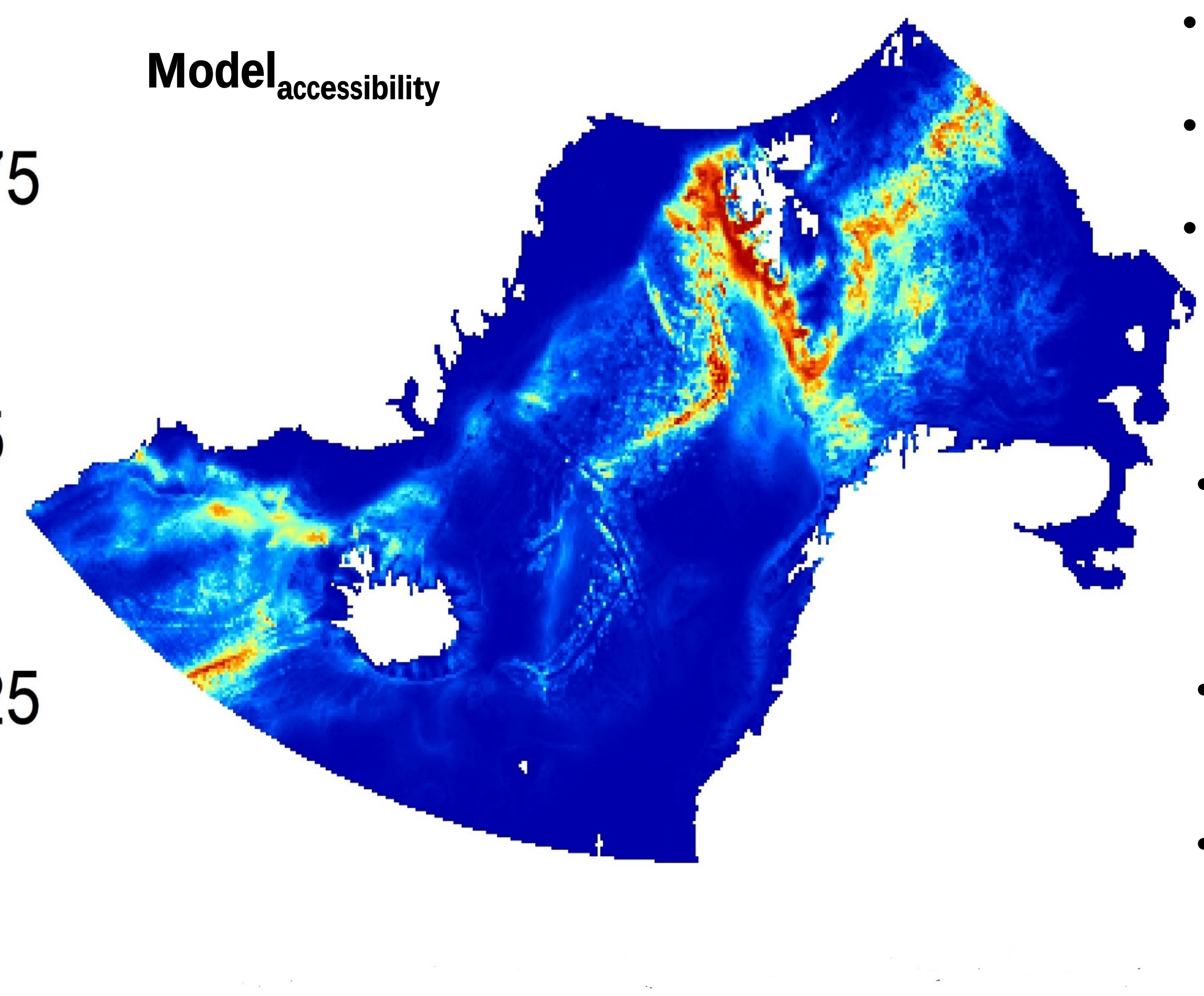
Spatial blocks for models with and without duplicates, as estimated by *spatialBlock* function

Results

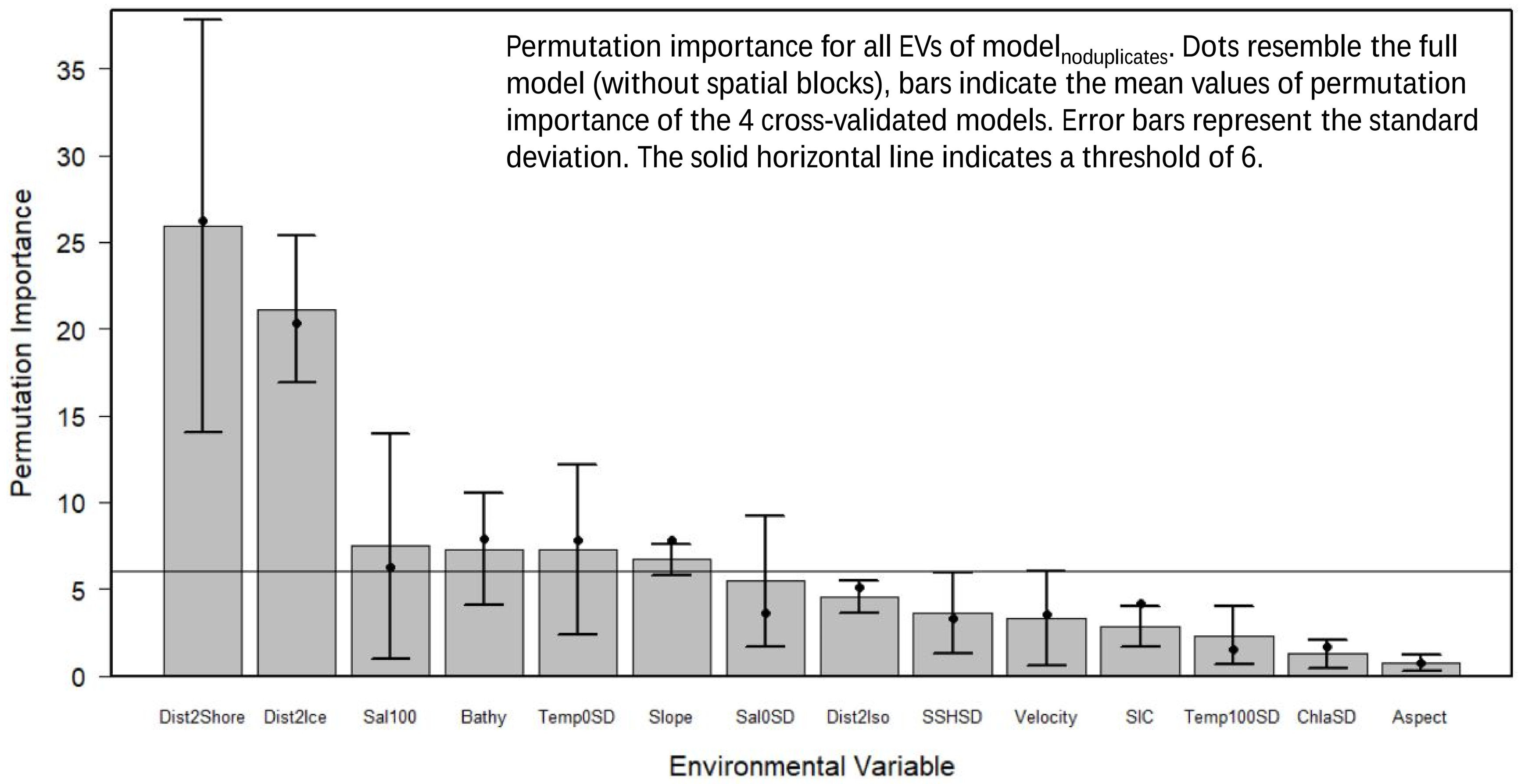
Both models show a similar predicted pattern, but habitat suitability seems to be rather extensive and not so clustered in the accessibility model.







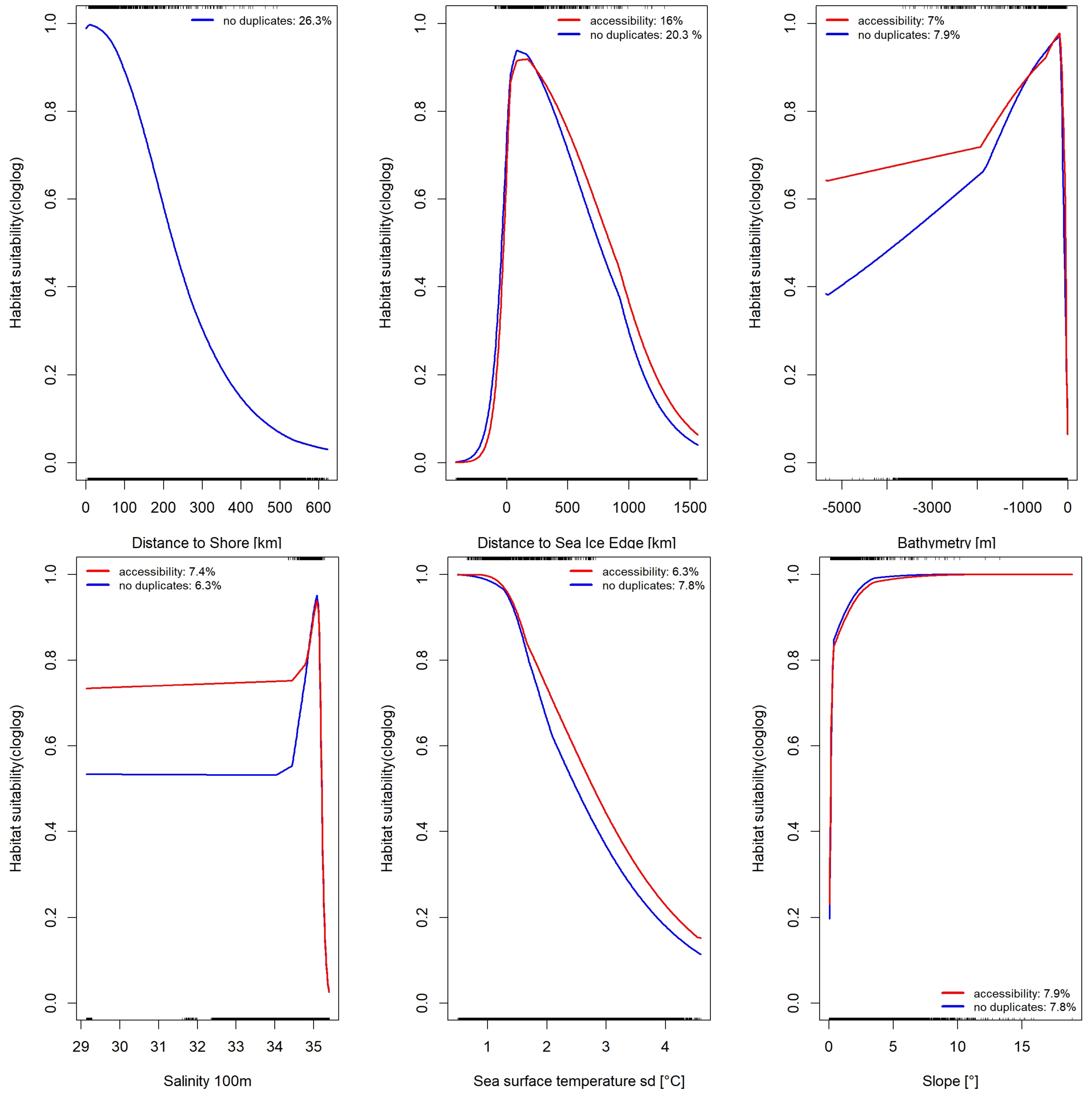
Prediction map for model$_{noduplicates}$ (left) and model$_{accessibility}$ (right). Habitat suitability ranges from 0 (blue; low) to 1 (red; high)



Permutation importance for all EVs of model$_{noduplicates}$. Dots resemble the full model (without spatial blocks), bars indicate the mean values of permutation importance of the 4 cross-validated models. Error bars represent the standard deviation. The solid horizontal line indicates a threshold of 6.

Habitat preferences of fin whales were mainly reflected by six environmental variables:

- Distance to shore and sea ice edge
- Bathymetry
- Slope
- Variability of sea surface temperature (SST)
- Mean salinity at 100 m



- A distance to shore of 10 km and 80 – 150 km to sea ice edge has the highest habitat suitability
- Fin whales favor a certain range of depth, suitability tends to increase as slope increases
- Little variation in SST is favored, while habitat suitability according to salinity 100 m was highest around 35

Discussion

- Two most contributing variables were **distance to shore** and **distance to sea ice edge**, indicating a strong relationship between habitat preference and these EVs
- Other variables, such as bathymetry and slope were shown to have an impact too, indicating a more complex interplay
- Results demonstrate the effective use of SDMs to predict species distributions in remote areas, constituting a cost-effective method for targeting future surveys and prioritizing limited conservation resources

Conclusions

Potential applications of results:

- Designing marine protected areas / guiding seismic surveys
- Support the further use of opportunistic data to understand ecological drivers of species distribution
- Targeting / designing future surveys

SDMs are useful tools to model species distribution using opportunistic data:

- Development and evaluation of mitigation systems
- Monitoring of distributional shifts

References [1] Budic et al. 2015 [2] Philipps et al. 2006 [3] Dudik et al. 2007 [4] Muscarella et al. 2014 [5] Valavi et al. 2018 [6] R Core Team (2017) [7] Warton et al. 2013