Modelling distribution patterns of sea ducks in the south-western Baltic Sea

Nina Oestereich*, Gin Swen Ham, Johanna Osterberg, Alexander Schubert, Ansgar Diederichs
BioConsult SH GmbH & Co. KG, Schobüller Str. 36, D-25813 Husum, Germany
* presenting author, n.oestereich@bioconsult-sh.de

Introduction

Common Scoters Melanitta nigra, Long-tailed Ducks Clangula hyemalis, and Common Eiders Somateria mollissima are sea duck species regularly found in the Baltic Sea especially during wintering periods1. Their small-scale distribution is typically dependent on mussel abundance, although inter- and intra-annual differences in their distribution occur that are not directly linked to mussel abundance[1].

Aims

The aim of this study was to examine the small-scale distribution of three species of sea ducks in relation to environmental and anthropogenic factors (water depth[2], sediment type[4], ship traffic[3], and presence of wind turbines[3]) potentially affecting their occurrence across space and time. Duck distribution data came from monthly aerial surveys in 2024 of the planned Kriegers Flak North and South offshore wind farms[3].

Methods

A generalized additive model (GAM) with a negative binominal distribution was fitted for each species to assess the influence of different parameters on species occurrence. The data got aggregated onto a spatial grid of 600 x 600 m to avoid multiple counts at the same locations from different months and to ensure equal spatial weighting in the model.

Conclusion

Overall, the distance to the closest offshore windfarm and to the closest ship had a significant influence on the distribution of all three analysed species, showing linear effects on the Common Scoters and Long-tailed Ducks, whereas the water depth showed no significant effect on the Long-tailed Ducks. The sediment type had no significant influence on the distribution of ducks. However, noticeable tendencies for presence or absence on specific substrate types can be found.

Common Scoter *Melanitta nigra*

The distribution of Common Scoters in the study area was significantly affected by the water depth and the distance to the closest ship. These parameters show non-linear effects, whereas the distance to the closest offshore wind farm indicates a significant, close to linear effect. The sediment type seemed to have no influence on the distribution Common Scoters.

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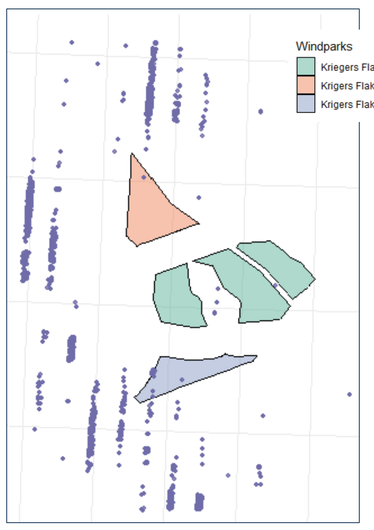

Distribution of Common Scoters in the study area

Table of the tested parameters and their impact on the distribution of Common Scoters

Parameter	Estimate	Std. Error	Lower CI (95%)	Upper CI (95%)	P-Value
(Intercept)	3.406	0.101	3.208	3.604	> 0.001
Coarse-grained sediment	-0.807	0.685	-2.149	0.535	0.239
Mixed sediment	-0.028	0.210	-0.439	0.384	0.896
Smooth term	**EDF**	**Ref.df**	**Chi.sq/F**	**P-Value**	
s(depth, k = 14)	6.176	7.633	48.358	0	
s(distOWF_km, k = 7)	1.002	1.005	12.136	> 0.001	
s(distAIS_km, k = 8)	3.128	3.800	28.009	> 0.001	

Long-tailed Duck *Clangula hyemalis*

The distribution of Long-tailed Ducks was significantly affected by the distance to the closest offshore windfarm and the distance to the closest ship, which showed a linear effect. The water depth had no significant influence on the distribution, nor had the sediment type. Although, there is a slightly positive trend visible for the mixed sediment.

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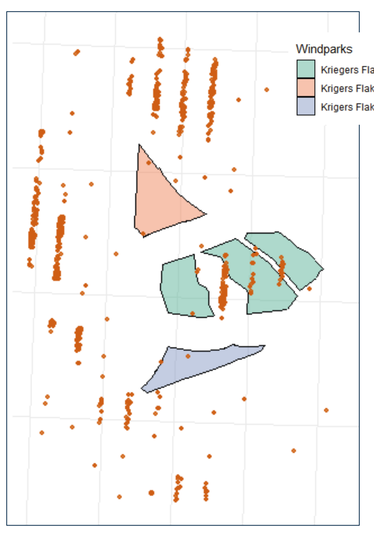

Distribution of Long-tailed Ducks in the study area

Table of the tested parameters and their impact on the distribution of Long-tailed Ducks.

Parameter	Estimate	Std. Error	Lower CI (95%)	Upper CI (95%)	P-Value
(Intercept)	1811	0.630	0.577	3045	0.004
Muddy Sand	-0.961	1039	-2998	1077	0.355
Sand	-0.294	0.637	-1542	0.954	0.644
Coarse-grained sediment	-0.725	0.764	-2222	0.772	0.343
Mixed sediment	1187	0.655	-0.097	2472	0.070
Rock & boulders	-0.382	0.997	-2336	1571	0.701
Smooth term	**EDF**	**Ref.df**	**Chi.sq/F**	**P-Value**	
s(depth, k = 13)	2167	2813	4750	0.142	
s(distOWF_km, k = 6)	2837	3442	20349	> 0.001	
s(distAIS_km, k = 3)	1000	1000	11418	> 0.001	

Common Eider *Somateria mollissima*

The distribution of Common Eiders was significantly affected by the water depth, the distance to the closest offshore windfarm and the distance to the closest ship, none of these parameters showed a linear effect. The substrate seemed to have no influence on the distribution of Common Eiders, although there is a negative trend in the distribution visible for rock and boulders in the sediment.

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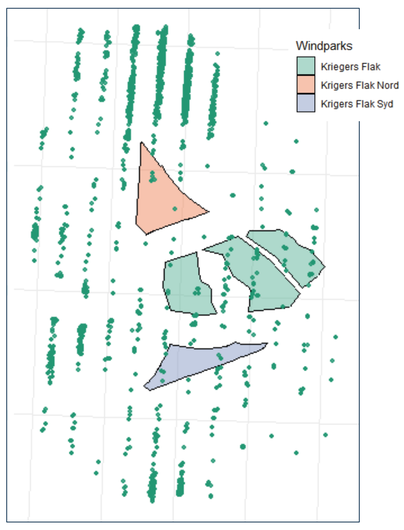

Distribution of Common Eiders in the study area

Table of the tested parameters and their impact on the distribution of Common Eiders.

Parameter	Estimate	Std. Error	Lower CI (95%)	Upper CI (95%)	P-Value
(Intercept)	2512	0.302	1919	3104	> 0.001
Sandy Mud	0.714	0.736	-0.729	2168	0.332
Muddy Sand	-0.627	0.390	-1392	0.138	0.108
Sand	0.045	0.315	-0.574	0.663	0.888
Coarse-grained sediment	-0.662	0.427	-1500	0.175	0.121
Mixed sediment	-0.010	0.336	-0.668	0.649	0.977
Rock & boulders	-1399	0.818	-3003	0.205	0.0873
Smooth term	**EDF**	**Ref.df**	**Chi.sq/F**	**P-Value**	
s(depth, k = 16)	7881	9645	46591	> 0.001	
s(distOWF_km, k = 7)	4005	4788	16036	0.004	
s(distAIS_km, k = 4)	2697	2927	19804	0.001	

References
[1] Mendel,B., N. Sonntag, J. Wahl, P.Schwemmer, H. Dries, N. Guse, S. Müller & S. Garthe (2008) Artensteckbriefe von See- und Wasservögeln der deutschen Nord- und Ostsee – Verbreitung, Ökologie und Empfindlichkeiten gegenüber Eingriffen in ihrem marinen Lebensraum. Nr. 59, In Naturschutz und Biologische Vielfalt, Bonn – Bad Godesberg (DEU), S. 437.
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