Harbour porpoises in the Fehmarnbelt area: Do they stay or do they go?

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INTRODUCTION

Several studies on the occurrence of harbour porpoises in the Western Baltic Sea showed a clear seasonal pattern with highest numbers during spring and autumn and lowest numbers during winter and summer, which is often discussed as a result of porpoises following fish stocks from the Belt Sea into the Baltic Proper.

However, results from satellite telemetry could not show any consistent "migratory pattern" of tagged animals in the Western Baltic Sea and information on the key factors that govern the distribution of harbour porpoises in this area is still missing.

We conducted a two year study on porpoise presence in the Fehmarnbelt area, located within the Western Baltic, using autonomous porpoise click detectors (C-PODs) in order to identify possible covariates, which explain porpoise presence.

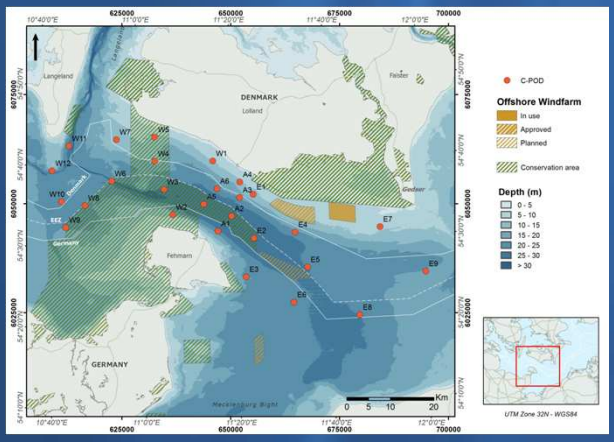

Figure 1: Study area with 27 C-POD stations.

METHODS

C-PODs were deployed at 27 locations in the wider Fehmarnbelt area for a period of two years (Figure 1).

The number of pp10m/day (porpoise positive ten minutes per day) were modeled using 27 continuous and categorical covariates inside GAMs with a logit link and binomial errors. The smooth functions were implemented using cubic B-splines with one interior knot on the scale of the link function.

Furthermore, a GEE approach was chosen due to temporal autocorrelation of the dataset, as it can incorporate the temporal autocorrelation during the modeling process. Model covariates were selected by an exhaustive procedure, selecting all possible subsets based on an objective score appropriate for GEEs (e.g. QICu).

RESULTS AND DISCUSSION

The by far most important covariate was POD-ID (Tab.1) due to high differences in sensitivity between PODs. In order to test for a possible masking effect, POD-ID was removed from the final model. Exclusion of POD-ID did not change the explanatory power of most covariates or the actual relationship, so that data interpretation is robust when including POD-ID.

Table 1: Covariates with associated (marginal testing) p-values based on robust estimates of precision from the GEE-based model. Grey shading represents statistical significance at the 5% level. Reduction in pseudo R^2 represents the % reduction in the pseudo R^2 when each variable was omitted.

Covariate Selected	p-value	Loss in pseudo-R^2 when omitted
POD-ID	**< 0.001**	**31.60%**
Longitude	**< 0.001**	**6.27%**
Distance to shipping lane	**< 0.001**	**4.11%**
Background Noise	**< 0.001**	**2.97%**
Temperature at surface	**< 0.001**	**1.56%**
Year	**< 0.001**	**1.43%**
Water depth	**< 0.001**	**1.13%**
Substrate	**0.016**	**1.09%**
Month	0.541	1.00%
Latitude	**0.006**	**0.90%**
Density at surface	0.291	0.40%
Current gradient at surface	**< 0.001**	**0.36%**
Current speed at bottom	**< 0.001**	**0.35%**
North-south current velocity at surface	**< 0.001**	**0.31%**
Pycnocline strength	0.086	0.30%
East-west current velocity at surface	0.178	0.23%
Absolute value of vertical current velocity	0.249	0.21%
Vorticity at bottom	0.246	0.19%
Salinity discharge	**0.003**	**0.18%**

With Latitude and Longitude the geo-coordinates clearly show specific sub-areas to be important. The two noise related covariates 'Distance to shipping lane' and 'Background noise' show that porpoises seem to avoid areas of high noise. Hydrodynamic covariates like current related features contribute relatively little explanatory power. Only water temperature shows a clear relationship with maximum porpoise detections at 6°C (Fig.2).

Porpoise detections were very similar across months (Fig.3). While during the summer months pp10m/day was approximately 1.5 times higher than in January, there was a large amount of uncertainty about any month-to-month differences.

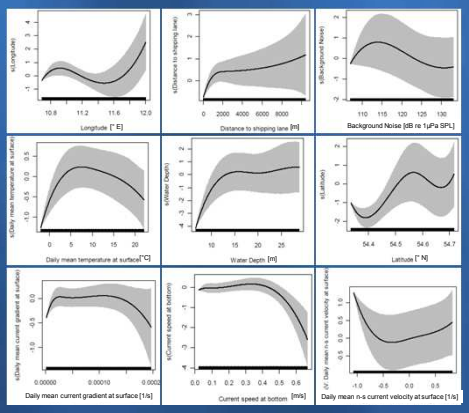

Figure 2: Fitted relationships from the chosen model with (pointwise) 95% confidence envelopes based on GAM/GEE standard errors.

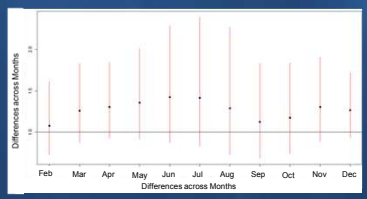

Figure 3: Exponentiated Month-based coefficients from the chosen model with 95% confidence intervals based on GEE standard errors. All coefficients are with reference to January which is represented by the horizontal line. These coefficients represent the difference between each month and January in terms of the odds of success versus failure to record porpoises..

CONCLUSIONS

The presence of harbour porpoises in the Fehmarnbelt area seems to be driven, either primarily or secondarily, by a complex mix of location specific environmental conditions.

Seasonality occurs but the data yield no evidence for a regular migration pattern of harbour porpoises.

Hydrodynamic covariates revealed only minor effects on the presence of porpoises, at least at a daily scale.

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