Temporal trend and seasonal dynamics of harbour porpoises in Pomeranian Bight (Baltic Sea)

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Introduction

The presence of harbour porpoises in Pomeranian Bight (Baltic Sea) was monitored from 2005 - 2012 using Porpoise Detectors (PODs) – automatic acoustic devices detecting clicks of porpoises. The goal of this study is to estimate trends based on these data.

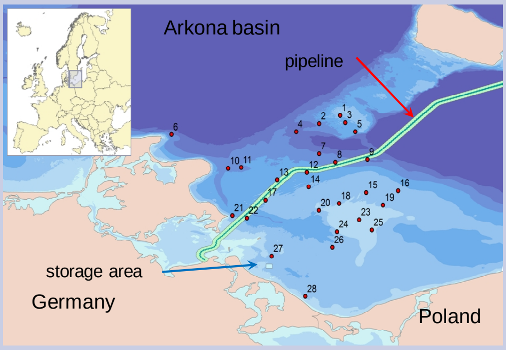

Fig. 1. The map of the study area. Dots show the location of POD stations.

Methods

A mix of T- and C- PODs were deployed at 28 stations (Fig. 1) where data were collected intermittently (Fig. 2). In the autumns of 2010 and 2011, a gas pipeline was built through the study area. A generalized additive model (GAM) framework was used to fit and compare models with porpoise positive days per month (PPDPM) as the response variable. Spatial, temporal and environmental variables were used as potential explanatory variables (Table 1).

Variables were included in four stages (Table 1) so that variables potentially important to the distribution of porpoises and detection by the POD were included before the more artificial variables: (1) Biologically meaningful variables and POD variables, (2) Variables related to construction and pipeline (construct, dist.pipe, dist.storage, dist.disturb), (3) Location variables (latitude and longitude), (4) Temporal variables (year, month and mid.date).

Models were chosen using forward selection and the models were checked for any non-significant terms and linear smooth terms before including the next set of variables. Interactions were also considered to account for differences in the response to the pipeline and storage area when construction was taking place and for differences in seasonal patterns between years.

Results

Harbour porpoise presence in the study area has a clear seasonal pattern with peak of porpoise detections in July-October (Figure 2). In a first approach the best fitted model explains 59% of the deviance. The model includes characteristics of stations (station number and POD type), location of the station within Pomeranian Bight, environmental parameters (temperature, bottom oxygen saturation at Arkona basin, chlorophyll A concentration at Pomeranian Bight, ice cover), fish biomass (Fig.3), and timing of construction activity and seasons. A diagnostic plot of the model is presented on Fig. 4.

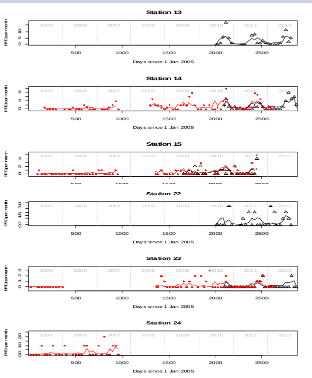

Fig. 2. Number of porpoise positive days per month (PPDPM). T-POD results are red dots and C-POD results are black triangles. The lines are the fitted values and the vertical axes are different for each station.

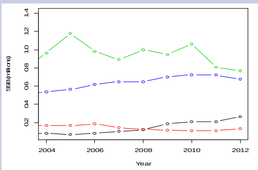

Fig. 3. Annual variables for fish species: spawning stock biomass (SSB) of cod (black), herring-3a22 (red), herring-2532 (blue) and sprat (green).

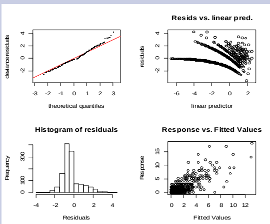

Fig. 4. Diagnostic plot for selected model.

GAM: Station + type + ice.gb + s(cod.SSB) + s(oxy.arc40) + s(temp.arc7) + s(chlora)+ s(dist.storage,by=construct) + s(month,by=year) + s(mid.date)

Table 1. Covariates used for modelling.

Category	Variable	Stage	Description
Environmental	station	1	Station (28 locations)
	type	1	POD type (C-POD or T-POD)
	construct	2	Construction taking place, monthly (1=yes or 0=no)
	sediment	1	Sediment type (6 levels)
Temporal	year	4	Year (8 years)
	month	4	Month (fitted as a cyclic smooth)
	mid.date	4	Median date of the month (since 1 Jan 2005) of deployment
	cod.ssb	1	Spawning stock biomass of cod in ICES subdivisions 25-32
	her1.ssb	1	Spawning stock biomass of herring in ICES subdivisions 22-24 and ICES division IIIa (Skagerrak, Kattegat and Inner Danish Waters)
	her2.ssb	1	Spawning stock biomass of herring in ICES subdivisions 25-29 and 32 and Gulf of Riga
	spr.ssb	1	Spawning stock biomass of sprat in ICES subdivisions 22-32
	cod.sum	1	Annual sum of cod specimens from 3 sectors in study area within ICES 24
	her.sum	1	Annual sum of herring specimens from 3 sectors in study area within ICES 24
	spr.cod	1	Annual sum of sprat specimens from 3 sectors in study area within ICES 24
	ice.gb	1	Accumulated areal ice volume of the German Baltic Sea
	ice.cov	1	Maximum annual ice cover of the entire Baltic Sea
	oxy.arc40	1	Mean monthly % oxygen saturation in Arkona basin at 40m depth
	temp.arc7	1	Mean monthly water temperature in Arkona basin at 7m depth
	chlora	1	Monthly mean of chlorophyll A from 4 stations in study area, (mg/m^3)
Spatial	lat	3	Latitude of station (degrees)
	lon	3	Longitude of station (degrees)
	dist.storage	2	Distance to storage area of removed sediments (km)
	dist.stones	2	Distance to nearest stones at the bottom (km)
	dist.pipe	2	Distance to 1200m buffer zone around pipeline
	dist.disturb	2	Minimum distance to disturbance from pipeline or storage area
	depth	1	Water depth at station (m)

Conclusion

Our first model approach showed that porpoise presence in the Pomeranian Bight can be fitted as a function of several static and dynamic variables. Further development will improve the model with more environmental parameters.

Acknowledgment

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