Effects of Vibro Piling and ship traffic on the abundance and behavior of harbor porpoise (*Phocoena phocoena*)

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The construction of offshore wind farms is accompanied by considerable noise emissions during impulse pile driving and associated ship traffic, besides the common ship traffic (e. g. cargo ships). Several studies demonstrate a clear avoidance behavior of harbor porpoises (*Phocoena phocoena*) due to underwater noise. In the present research project "VISSKA" vibro pile driving method, a method with lower noise emissions compared to impulse pile driving, was used during the construction of an offshore windfarm in the German North Sea. We had a closer look at avoidance behavior of harbor porpoise due to construction noise of impulse pile driving versus vibro pile driving as well as associated ship traffic.
"VISSKA" is the German acronym for a research project aimed at exploring the use of vibro pile driving at the offshore wind farm "Kaskasi II", in terms of installation, noise emissions and the impact on the behavior of porpoises.

Methods:

Harbor porpoise data

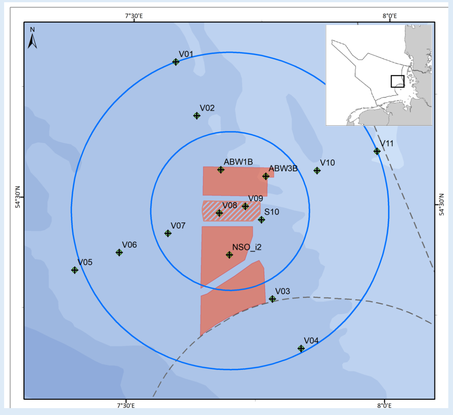

Fig. 1 17 C-POD positions were used during „VISSKA".

- Passive acoustic monitoring (PAM; C-PODs) via continuous recording June 2021 to May 2022
- 17 C-POD positions, inside and outside the OWP (0-22 km from center)

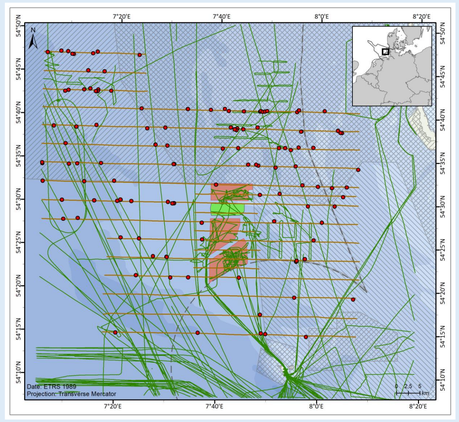

Fig. 2 Aerial survey transects over a 1,906 km² study area.

- 7 digital aerial surveys (HiDef) in 2021 and 2022
- study area: 1,906 km²
- Transects divided in 1 km sections for density calculations

Ship data

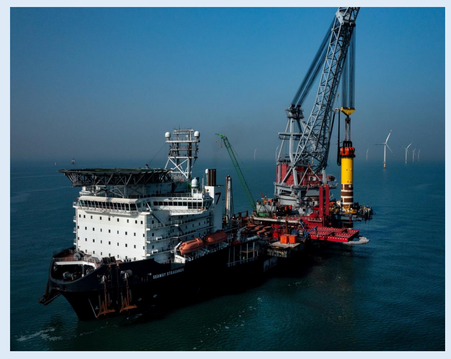

Fig. 3 Installation ship during offshore wind park construction. (Source: RWE)

- AIS data of ship positions
- For the analyses, only ships present during aerial surveys and PAM were considered.

Analyses

- Aerial survey transect divided into 1 km sections for harbor porpoise density calculations.
- Buffers around each section of aerial surveys between 1 km and 5 km for ship presence calculations.
- Buffers around C-POD positions of 5 km for ship presence calculations.
- Statistical analysis using generalized additive mixed models (GAMM)

Results – Avoidance behavior of harbor porpoise during Vibro Piling

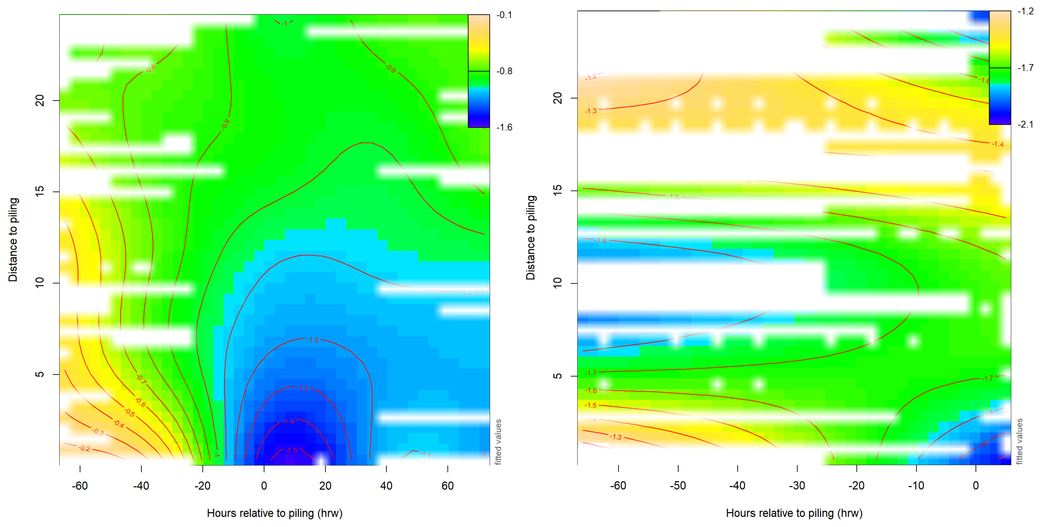

Fig. 4 Harbor porpoise density change before and after impulse pile driving (left) and vibro pile driving (right) in comparison to base data taken in the same area before construction started. Color coding (uper right) shows the difference in harbor porpoise desity over time (x axis) and distance (y axis).

- 6 out of 38 piles were installed via vibro pile driving. A direct comparison of vibro pile driving and impulse pile driving was possible.
- Avoidance effects on harbor porpoises based on vibro pile driving (mitigated) were seen in distances of up to 5 km based on PAM data (comparison: Impulse pile driving up to 13 km)
- Vibro pile driving emits lower frequencies than impulse pile driving, which doesn't intervene with the high frequency range of echolocating harbor porpoise
- Harbor porpoises use high frequency echolocation for communication, preying and orientation, naturally their best hearing ability is also in high frequency ranges.

Results – Avoidance behavior of harbor porpoise in relation to ship traffic

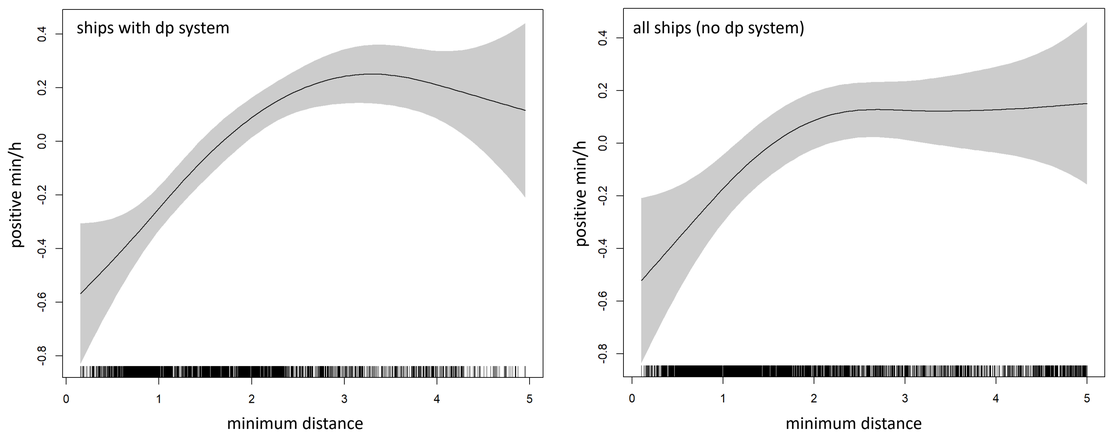

Fig. 5 Harbor porpoise detection positive minutes per hour (y axis) in relation to the minimum distance of either a ship with a „dynamic positioning system" (dp system) or all other ships (with no dp system; x axis).

- Avoidance effect to the next closest ship was stronger when a "dynamic positioning system" was in use, probably because of the emission of higher frequency noises (3 km compared to 2 km of usual ship propulsion noise)
- Significant avoidance effects were seen in relation to the number of ships on the detection rates of harbor porpoises in a 5 km radius around C-PODs and aerial survey sections
- No significant effect of ship speed, length and time since passage of the last ship was seen on harbor porpoise abundance

Conclusion

- It appears that vibro pile driving is less disturbing for the habor porpoise compared to impulse pile driving. Nonetheless, a definite statement cannot be made as the number of piles installed using vibro pile driving is very limited.
- It is assumed that the lower frequency emitted during vibro pile driving compared to impulse pile driving is an important factor for the observed difference in avoidance behavior.
- Harbor porpoises avoid areas with high ship traffic. Effects of ship type or speed have not been detected.
- The number of ships and the emitted frequency are important factors in ship avoidance.

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VISSKA Paving the Way for Vibro Piling