

**Quantifying harbour porpoise disturbance by offshore windfarm piling activities**

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The impact of pile driving on marine mammals is one of the major environmental concerns in offshore windfarm construction. We assessed the impact of pile driving on the spatiotemporal distribution of harbour porpoises during the season of maximum abundance in Belgian waters. We combined data collected by a small number of passive acoustic monitoring (PAM) devices, moored inside and outside the project area, and five standardized aerial surveys, covering the Belgian part of the North Sea ( $\pm 3600 \text{ km}^2$ ). The combination and integration of both techniques proved very useful as PAM results in low spatial but high temporal resolution data, while aerial surveys have a complementary low temporal but high spatial resolution. Just before construction activities started, aerial surveys yielded an estimate of 2.5 harbour porpoises per  $\text{km}^2$ , while after the start of the construction (piling) activities density estimates had decreased to 1.3 animals per  $\text{km}^2$ . Although a decreasing density towards the end of April in Belgian waters should be considered as normal (cf. seasonal migration), an obvious shift in spatial distribution between pre- and post-piling already suggested harbour porpoise disturbance. This pattern was further explored with PAM, which indeed showed a clear fine-scale match between PAM harbour porpoise detections and piling activities. PAM demonstrated that immediately upon the start of piling activities harbour porpoise detections fell to virtually zero, and that it took hours to days before new detections were made after the cessation of piling. Aerial surveys allowed us to quantify an impact radius of more than 20 km.

**Keywords:** Belgian part of the North Sea, harbour porpoise, offshore windfarms, pile driving.

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