

GERMAN REQUIREMENTS FOR PILE DRIVING

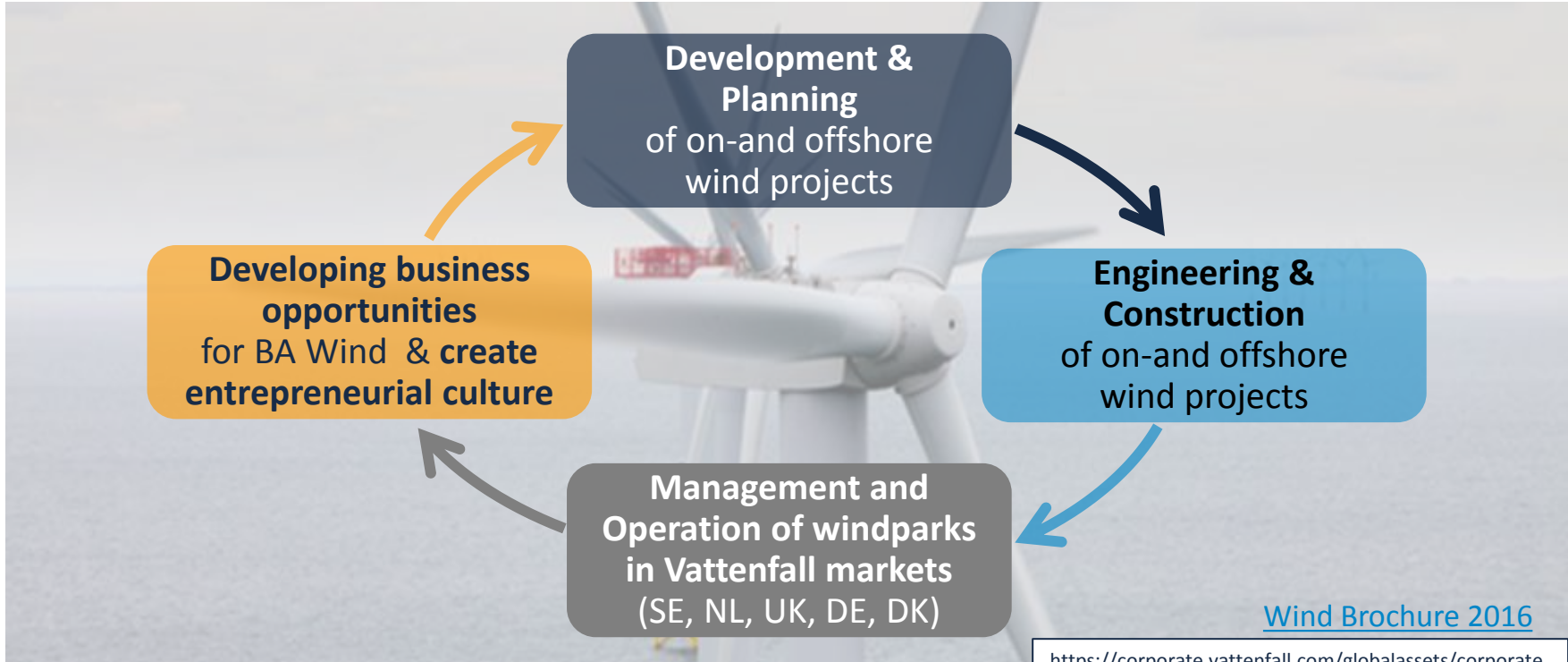
Experience from offshore windfarm
construction and deployment of noise
mitigation technologies

Washington D.C./08. March 2017/Dr. Eva Philipp

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VATTENFALL - WHAT ARE WE DOING WIND?



[Wind Brochure 2016](#)

https://corporate.vattenfall.com/globalassets/corporate/about_energy/brochure_wind_power_160921.pdf

OUR LARGEST OFFSHORE WIND FARMS IN DEVELOPMENT & OPERATION



Country	Name	Σ Turbines	Installed capacity (MW)
UK	Thanet	100	300
DE	DanTysk	80	288
DK	Horns Rev	79	158
UK	Ormonde	30	150
SE	Lillgrund	48	110
NL	Egmond aan Zee	36	108
UK	Kentish Flats	30	90
DK	Horns Rev 3	49	400
DE	Sandbank	72	288
UK	Aberdeen	11	91
DK	Kriegers Flak	tbd	600
DK	Danish Nearshore	tbd	350

VATTENFALL EXPERIENCE IN OFFSHORE WIND UNDERWATER NOISE REGULATION

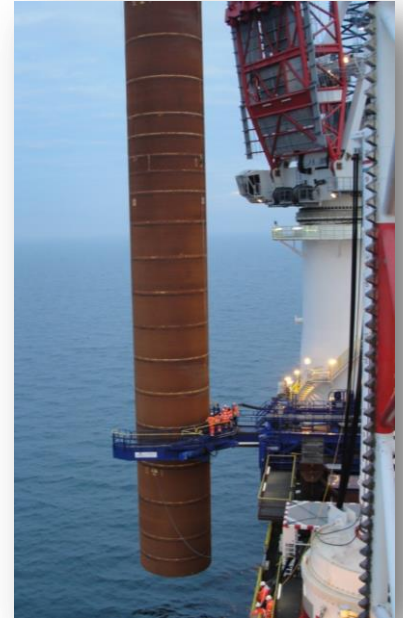
Strategic:

- Regular knowledge exchange with other windfarm developers, noise mitigation system -, hammer suppliers
- Involvement in GER, UK, NL and DK regulatory discussions
- Participation in several R&D projects (e.g. GESCHA, Depons)

Practical experience in Germany:

- OWP DanTysk: Installation of 80 MPs, Ø 6m, Mar 2013 – Dec 2013
- OWP Sandbank: Installation of 72 MPs, Ø 6.40-6.80m, July 2015 – Feb 2016

Dan Tysk ● Sandbank



NOISE MITIGATION REGULATIONS IN THE GERMAN EXCLUSIVE ECONOMIC ZONE (EEZ)

The impact of noise from piling activities on marine mammals, particularly harbor porpoises (*Phocoena phocoena*), has become a crucial aspect in the process of approving offshore windfarm projects in Germany.

Bundesnaturschutzgesetz – Federal law on nature protection

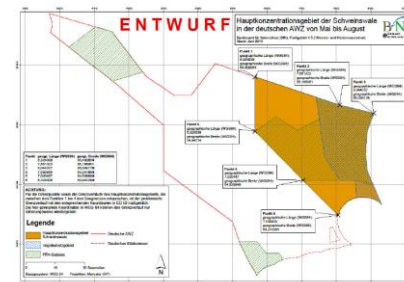
- Forbidden to injure (§ 44 Abs. 1 BNatSchG) —————> Individual
- Forbidden to significantly disturb (§ 44 Abs. 1 BNatSchG) —————> Population



To meet these rules for harbor porpoise, following measures were formulated with in the „Noise mitigation concept“ (2013) by the Federal Ministry for the Environment (BMU):

- threshold levels 160dB SEL and 190dB L_{peak} in 750m distance to the piling location (*also valid for permits before 2013*)
- max. 10% of German EEZ affected
- between May – August max. 1% of main-concentration area affected

Since 2015 - new piling regulation in practical implementation – max. 180min piling time (monopiles) including deterrence



NOISE MITIGATION CONCEPTS IN GERMANY

1. Noise prognosis

- Assess potential noise generation during foundation installation

2. Deterrence

- Displace animals from areas of high noise levels by means of Soft start or deterrence devices i.e. Pinger, Seal Scarer

3. Noise mitigation

- Mitigation of noise generation – decreased piling energy, alternative foundation installation
- Decrease of generated piling noise – Noise mitigation systems (NMS)

4. Monitoring / Control of efficiency

- Pre-, during & Post-construction monitoring
 - Document efficiency of noise mitigation by measuring underwater noise
 - Assess effect on harbor porpoise abundance by C-POD measurements



2. DETERRENCE

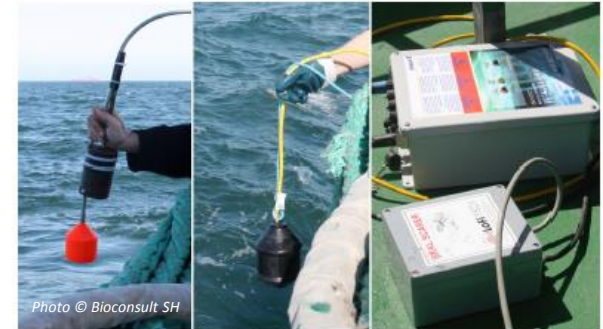
Soft Start:

In most cases required from technical point of view, depending on:

- Installation method (e.g. impulse piling, vibration)
- Installation spread (e.g. monopiles, jackets)
- Soil conditions (e.g. punch through)

Deterrence devices:

- Pinger & Seal scarer
- Low cost, easy to use
- Type and duration should be carefully chosen
 - in Germany in most cases 40min pinger + 30min sealscarer



3. NOISE MITIGATION

Mitigation of noise generation and decrease of generated piling noise depending on:

- Installation method (e.g. impulse piling, vibration, suction bucket)
- Installation spread (e.g. monopiles, jackets; jack-up or anchor vessels)
- Soil conditions (e.g. end depth needs to be reached)
- Site environmental parameter (e.g. currents, water depth)
- Weather conditions (weather windows / operational limits)



ALTERNATIVE FOUNDATION & INSTALLATION TYPES

- Offshore wind industry is looking into options but at present options still in development/prototype phase and tests + R&D needed.
- Even after successful test the feasibility of alternatives will depend on site specific (e.g. water depth, soil conditions, currents) and project specific (e.g. schedule, ship availabilities, installation logistics) factors.



Photo © Dong
Suction bucket at DONG BKR01

Jacket with suction buckets:

- Limited experiences in the wind industry - tested at DONG BKR01 and will be used in VF Aberdeen (EOWDC)
- Long term impact of cyclic/dynamic loads unknown
- Comprehensive knowledge of soil conditions necessary

Gravity Based Foundations:

- Used mainly near shore with low water depth
- Solid soil conditions, also in the upper layers required
- Several installation steps: seabed preparations, installation, ballasting with rocks etc.
- Heavy constructions, big impact area to the seabed

Drilled Foundations

- Several concepts developed in the past but at present no new development

Floating Foundations:

- Deep water solution
- No experiences in the wind industry
- Fixation of foundations on the seabed (anchors etc.)

Vibrated Monopiles:

- R&D VIBRO project showed less bearing capacity of vibrated piles compared to driven piles
- Sudden resistance might require change to impulse piling
- Currently not allowed in Germany to vibrate complete pile (last meters have to be driven)
- Lower noise impact but other frequency level...impact?

Blue piling foundation installation

- Possible lower noise generation
- Full scale offshore test still needed – planned 2017



Photo © Vattenfall
Suction bucket trial at Vattenfall Aberdeen OWP



Photo © Fistuca
Blue piling hammer manufact. for full scale test

STATUS NOISE MITIGATION SYSTEMS (1/4)

Bubble Curtain system



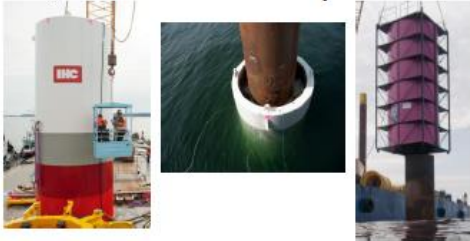
- Guided & unguided „Little Bubble Curtain“
- Small Bubble Curtain (Menck)
- Big Bubble Curtain (HTL, Weyres)

LBC

SBC

BBC

„Shell-in-shell“ system



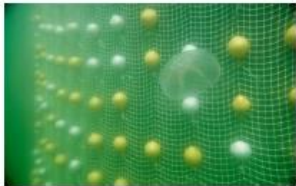
- Noise Mitigation Screen (IHC)
- Cofferdam & shell-in-shell constructions
- BeKa shell (Weyres Offshore)
- Fire Hose Methode (Menck)

IHC-NMS

BeKa

Most tested systems

other systems



- Pile wrapped with foam
- Hydro-Sound Damper
- Resonator system (AdBm)
- HydroNas (W³GM)
-

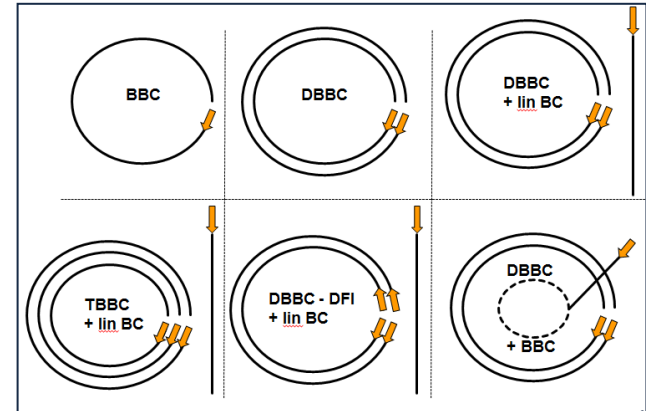
HSD

Taken from Bellmann et al . 2016

STATUS NOISE MITIGATION SYSTEMS (2/4)

NMS system effectivity:

- NMS/deterrence still to be adapted to each project due to site specific constraints. Learning curve for each project is necessary.
- 1 system: 10dB (up to 15dB)
- 2 systems: 15dB (up to 20dB)
- Reduction in blow energy: 1-4 dB noise reduction



(Noise reduction numbers taken from Bellmann et al . under review)

STATUS NOISE MITIGATION SYSTEMS (3/4)

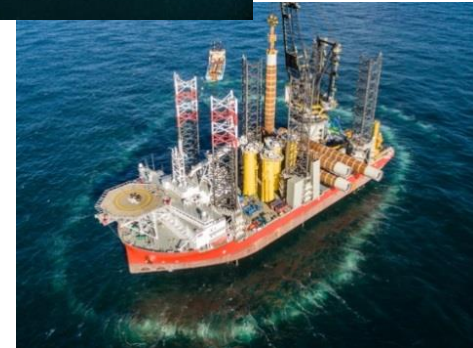
NMS reliability and constrains:



STATUS NOISE MITIGATION SYSTEMS (4/4)

NMS reliability and constrains:

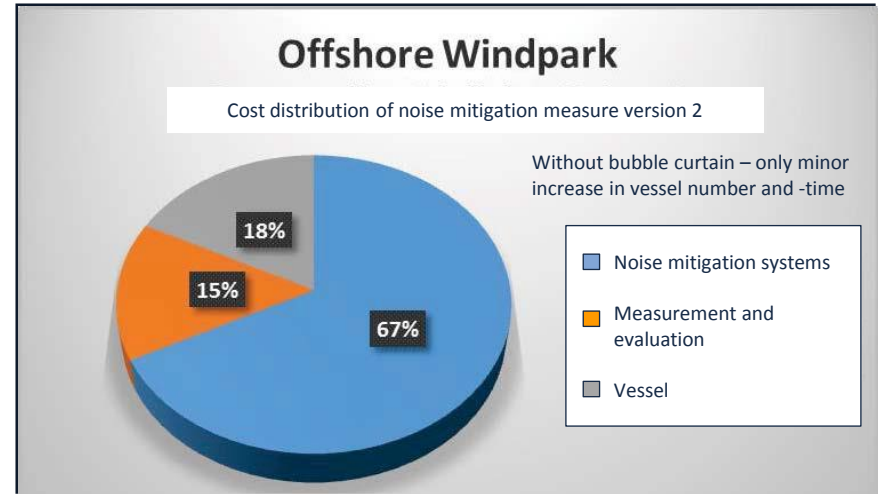
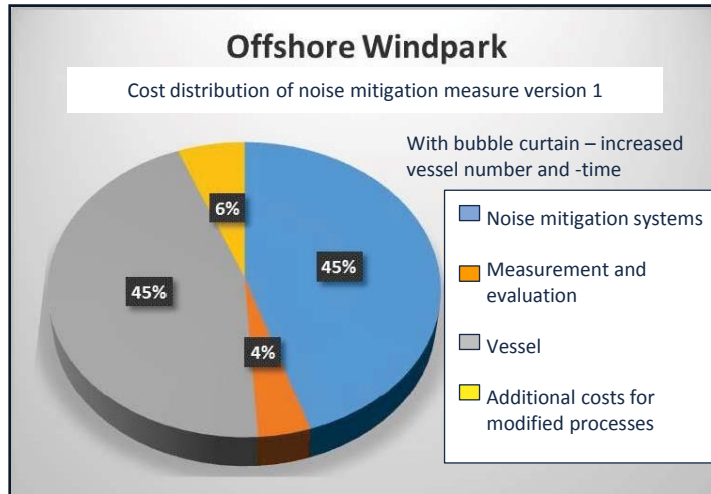
- Water depth > 40m no state-of-the-art available
- Limited number of suppliers and systems
- Even more limited proven options for Jackets apart BBC
- Still technical challenges and H&S risks
- Increase in resource use, disturbance, emissions – ecological cost/benefit?
- Noise mitigation frequency still neglected
- Weak (but increasing) evidence base for impacts on species/individuals/populations is still a major challenge



Industry triggered evidence base: GESCHA / Depons / Aberdeen EOWDC R&D

COSTS OF NOISE MITIGATION

- Costs of Noise mitigation concepts (NMS system, measurements) range between **15 – 36 Mio EURO**, equal to 10 – 30% of total foundation installation costs. See study [Technischer Schallschutz in Offshore Windpark Bauvorhaben](#)
- Several additional vessels needed for noise mitigation/ measurement and increased installation time which increases costs and HSE risk and may also increase environmental impact.
- Cost per day range between 250.000 – 350.000 EUR for installation spread, plus lost revenue, plus additional costs caused by knock on effects

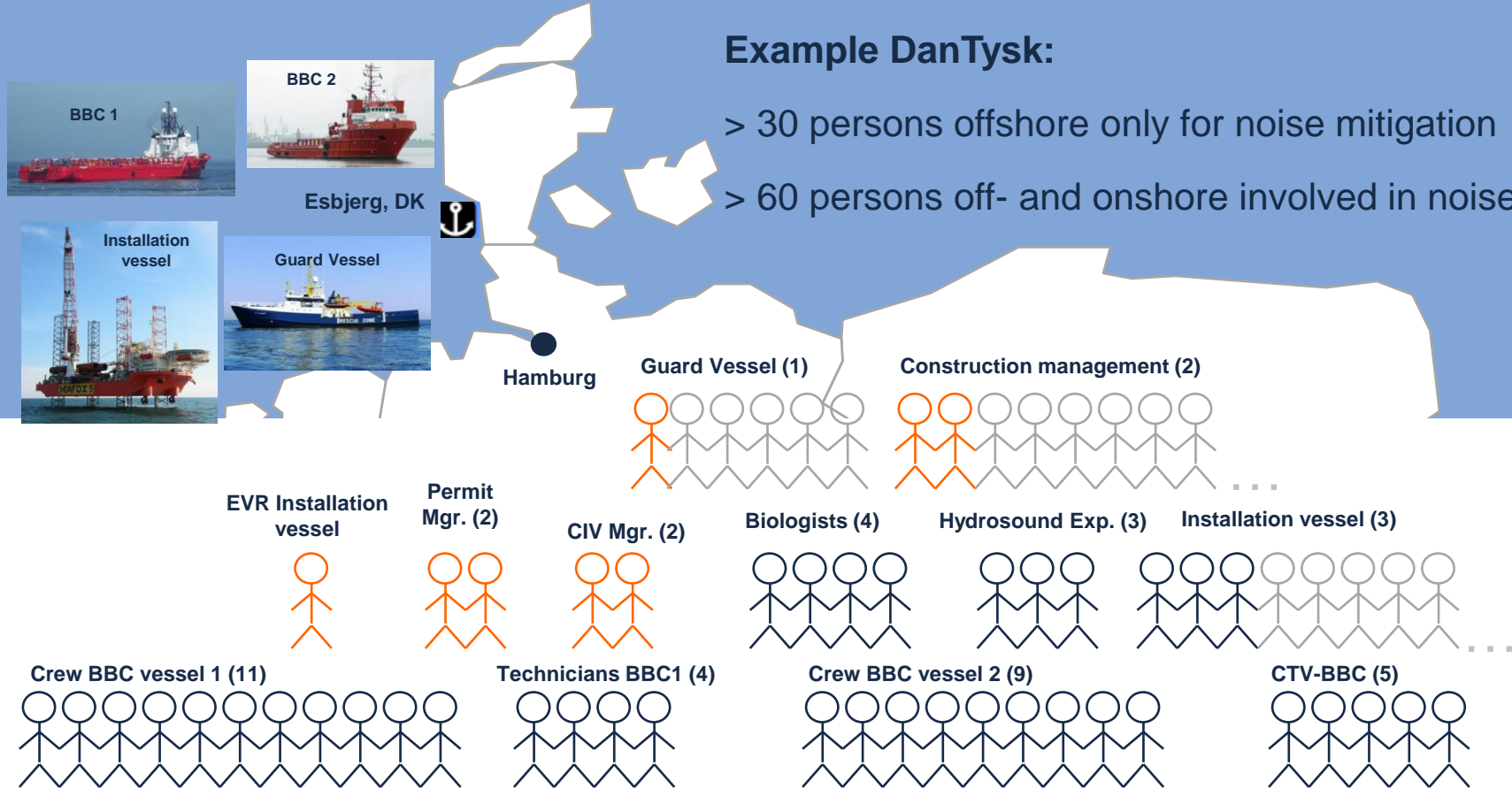


RESOURCES FOR NOISE MITIGATION

Example DanTysk:

> 30 persons offshore only for noise mitigation

> 60 persons off- and onshore involved in noise mitigation



4. MONITORING

In Germany, monitoring regulations described by the Bundesamt für Seeschifffahrt und Hydrographie (BSH) Standard



Standard

The 3rd update of the German version of the „Standard for Environmental Impact Assessment“

Format: DIN A4 - 86 pages

Year of publication: 2013

BSH-No: 7003

[Download \(free of charge\)](#) (PDF, 1593 KB)

Supplement to table 4.3:

[Measuring instruction for underwater sound monitoring](#) (PDF, 285 KB)

[Offshore Wind Farms Prediction of Underwater Sound Minimum Requirements on Documentation](#) (PDF, 393 KB)

[Offshore Wind Farms - Measuring Specification for the Quantitative Determination of the Effectiveness of Noise Control Systems](#) (PDF, 863 KB)

Since March 6th 2017 - New norm how to measure underwater noise during piling:

DIN SPEC 45653:2017-04 (D/E)

Offshore wind farms - In-situ determination of the insertion loss of control measures underwater

4. CONTROL OF EFFICIENCY

- C-POD and hydrosound measurements in 750 & 1500m distance from piling location during each installation
- Defined long-term monitoring stations pre-, during-, and post-construction
- Areal (digital) and ship based surveys
- Industry initiative: OWP specific R&D stations with hydrosound and C-POD devices

Used by industry to create
Evidence base

GESCHA study: “Study on the effects of construction of the first eight offshore wind farms in Germany on harbor porpoises 2010-2013”

Aim: Assessment of offshore pile driving effects on harbor porpoise abundance in the German Bight

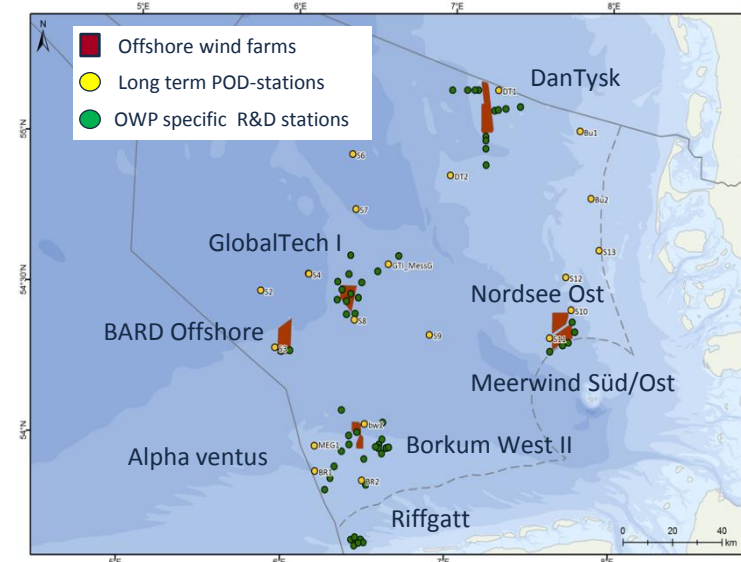
- What is the magnitude of disturbance caused by pile-driving on harbor porpoise and does that matter for the viability of the German Bight population?
 - JIP with 20 Partners led by the working group “Noise mitigation” of the Offshore forum Wind energy
 - Budget: ~370 kEUR
 - Timeline: 2012-2016

[Download study](#)

<http://www.offshore-stiftung.de/erstmalig-untersucht-rammarbeiten-von-offshore-windparks-haben-keine-negativen-auswirkungen-auf>

GESCHA - RESULTS

- No negative consequences for the harbor porpoise population, even increases in abundance seen in two of four areas
- Animals tend to avoid the pile driving area for a short time, with a clear distance-based gradient
- Avoidance observed for all pile driving work with and without noise mitigation >143 dB(SEL) for a distance of up to 17 kilometers (with NMS up to 14 kilometers)
- Even in areas with >155 dB(SEL), some animals remained present
- No cumulative effects or indication of adaptation or being more sensitive as a result of increased pile driving in the time period of this study

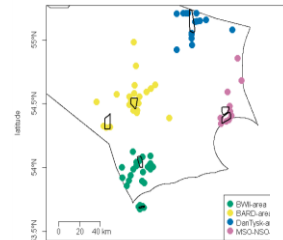


OFW: Harbour Porpoises in German Bight Unaffected by Pile Driving

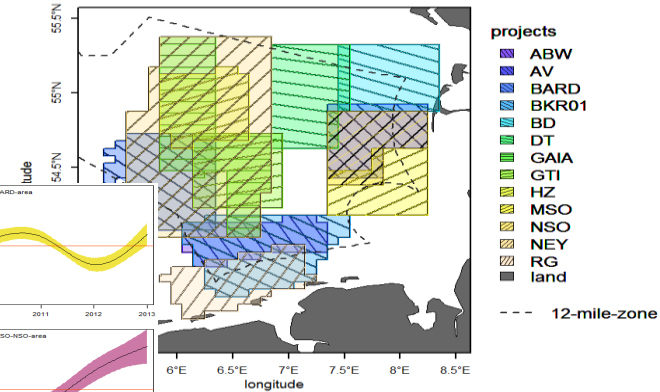
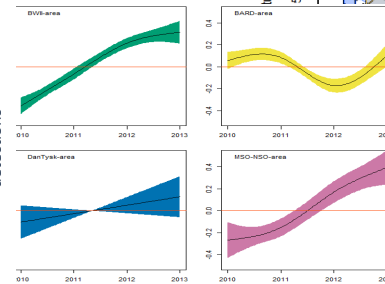


Pile driving during construction of offshore wind farms in the German North Sea has little to no effect on local harbour porpoise population, according to a study commissioned by the Offshore-Forum Windenergie (OFW) in partnership with the offshore wind industry leaders.

"The study shows that offshore wind farms have



Deviance of porpoise daily detections



GESCHA II...?

TECHNICAL / LOGISTICAL CONSTRAINS (1/2)

Installation schedule/time is difficult to plan due to delays, prolongation, changes caused by (all examples from experience):

➤ **Design & Manufacturing:**

- Design certification
- Steel plate delivery

➤ **Installation:**

➤ Onshore Loading:

- Weather
- Crane failure
- HSE, process incidents

➤ Offshore equipment failure such as:

- Positioning / jacking of vessel

➤ Hammer (Power pack, Hydro-System)

➤ Pile gripper

➤ Horizontal survey tool

➤ Crane

➤ NMS

➤ Weather

➤ Geotechnical conditions

➤ UXO

Difficult to comply with new German max. piling time regulation

One issue can be dealt with but in most cases several issues come together!

TECHNICAL / LOGISTICAL CONSTRAINS (2/2)

- Installation spread is fixed 1 year before construction i.e. no possibility to change setup anymore
- Installation sequence is fixed once manufacturing (~1year before construction) and construction has started e.g. due to cable string planning, set of foundations adjusted to ship bearing capacity.
- Noise mitigation systems can decrease deck space and lead to increased installation time due to higher numbers of installation cycles.
- Majority of alternative installation techniques (e.g. drilling) still under development e.g. installation to complete depth not completely predictable for all techniques potentially leading to a necessary shift to impulse piling.
- Any Offshore work needs to be planned in detail (method statements) and approved upon with involved parties e.g. authorities, insurance, certifier i.e. possibilities for short-time changes limited
- HSE is a high priority for all companies! Introduction of any mitigation tool will lead to an increased HSE risk.

MANAGEMENT MEASURES

– BASIC CONSIDERATIONS FROM GERMAN EXPERIENCE



- Renewable energy helps to achieve government climate change targets
- High environmental restrictions can reduce investor confidence and regulations only directed to offshore windfarm industry can put an economic imbalance on this sector compared to others e.g. oil and gas seismic
- Cost reduction targets should be kept in mind when choosing environmental regulations.
- Early transparency in regulation is crucial for proper project planning (especially in tender systems)
- Mitigation measures should be based on a clear evidence based rationale, that can and will be reviewed and updated as new evidence is building up
- Strategic work should include all stakeholders including industry experience of challenges during offshore installation and operation
- High flexibility for developers in terms of means adopted to meet noise measures important due to project specific needs
- Cost / benefit of noise mitigation and renewable energy production should be assessed – holistic assessment

A photograph of an offshore wind farm at sunset. The sky is a mix of orange, yellow, and grey, with the sun low on the horizon. Five wind turbines are visible, silhouetted against the bright sky. The water in the foreground is dark and textured.

**Thank you for your
attention**