NOISE MITIGATION IN GERMAN OFFSHORE WIND CONSTRUCTION SINCE 2014

PRACTICAL EXPERIENCE AND INFLUENCE OF PILE DRIVING ON HARBOUR PORPOISE

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OFFSHORE WIND R&D Conference, Bremerhaven 15. November 2018

Bundesverband der Windparkbetreiber Offshore e.V. (BWO)

The Association of German Wind Farm Operators

Formerly: AGOW

17 Members

- Companies involved in planning, construction and operation of offshore wind parks
- All wind parks currently operational and under construction in the German North and Baltic sea

What We Do

- Derive political recommendations from members' expertise
- Enable the exchange of information between members
- Promote the development of offshore wind power

Political Demands

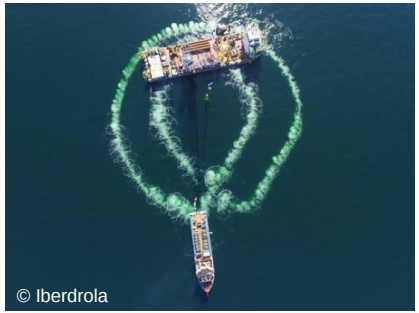
- Expand offshore capacity in Germany by 20GW by 2030
- Use all available converter capacity
- Expand the major transmission systems

Working Groups

- WG Engineering
- WG O&M
- WG Politics
- WG Environment
- WG Legal Framework

Presentation overview

- Underwater noise management in Offshore Wind projects
- Current Noise mitigation measures – Deterrence, mitigation, control of efficiency
- Research and development - to understand and reduce environmental impacts
- Summary



Underwater noise during installation

Environmental regulations & impact knowledge :

Country specific approaches range from:

- Impact assessment based on individuals / populations, injury / disturbance, accumulation / direct, frequency weighted/unweighted,
- generic guidelines <-> each time project specific
- monitoring & mitigation to be conducted completely from developer/WF owner <-> completely from authority
- monitoring & mitigation methods differ between countries

- **Weak (but increasing) knowledge base** for impacts on species/individuals/populations is a major challenge
- **Strategic work needed** – all need to come together **– we are ready! (already engaged)**
  - Increase evidence base from OWF monitoring, **remaining uncertainties** about injury & disturbance risk
  - Take **industry experience** on technical / operational and timeline constrains into account

Underwater noise – the concept in Germany

Construction and pile-driving activities in the marine environment can cause disturbance and underwater noise, which may affect marine mammals such as harbour porpoises

Impact of noise from pile-driving on marine mammals, especially harbor porpoises, has become a crucial aspect in permit process of offshore windfarms in Germany and other EU countries.

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 SEL_{ss} 160 dB re 1µPa^{2}s and SPL 190 re 1µPa in 750m distance to the piling location
- 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 in German OWPs

Noise prognosis

- Assess potential noise generation during foundation installation

Deterrence

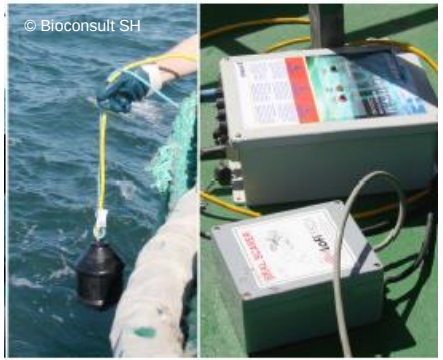
- Displace animals from areas of high noise levels by e.g. Soft start or deterrence devices

Noise mitigation

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

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



Deterrence

Displace animals from areas of high noise levels e.g. Soft start and ramp up and/or deterrence devices i.e. Pinger, Seal Scarer (ADDs)

Soft Start:

- In most cases required from permitting authorities but moreover 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:

- Low cost, easy to use, effective
- Type and duration should be carefully chosen (e.g. Fauna guard)

Current industry experience/practice:

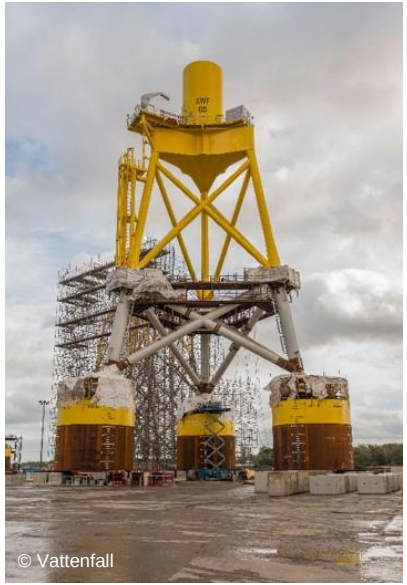
- Deterrence mostly from the installation vessel or from „Bubble Curtain Vessel“
- 1-3 pingers 40-50 min. before start of piling or operation of NMS
- 1-2 Seal Scarer 30-40 min. before start of piling or operation of NMS (parallel to pinger)
- Since 2018 “Fauna Guard” device as alternative deterrence system – species frequency specific deterrence and reduced to 30min

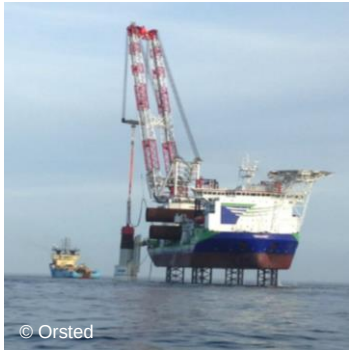
Noise mitigation

Mitigation of noise generation and /or attenuation of generated piling noise

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)
- Weather conditions (weather windows / operational limits)
- Site environmental parameters (e.g. currents, water depth)



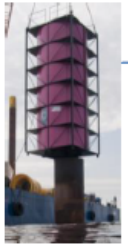


Noise mitigation systems

Bubble Curtain system

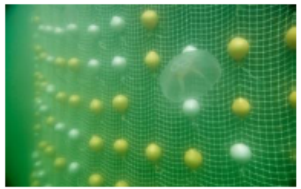
- Guided & unguided „Little Bubble Curtain“ LBC
- Small Bubble Curtain (Menck) SBC
- Big Bubble Curtain (HTL, Weyres) BBC

„Shell-in-shell“ system



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

other systems



- Pile wrapped with foam
- Hydro-Sound Damper HSD
- Resonator system (AdBm)
- HydroNas (W^3GM)
- …..

Most used systems

Taken from Bellmann – Offshoretage 2018

Noise mitigation - current industry experience/practice

Noise mitigation systems used 2011-2018 for WTG foundations

FOU Constr. Year	OWP Project	No of foundations & Ø	Big Bubble curtain variation (BC; Small (S), Double (D), Triple (T), Linear (L))	Sleeve solutions (IHC NMS, Hydrosound damper (HSD))	Water depth
2018	Hohe See	71 MPs , Ø 8m	BBC, DBBC	IHC	40m
2017	Arkona	60 MPs, Ø up to 7,75m	DBBC	HSD	23- 37m
2017	Merkur	66 MPs, Ø 7,6 m - 7,8m	BBC	IHC	28 - 32m
2016/17	Wikinger	70 jackets, 4 piles, Ø 2,7m	DBBC, SBC	HSD stand by	36 - 42m
2017	Nordsee One	54 MPs, Ø 6,7 m	BBC	IHC	26 - 29m
2016	Nordergründe	18 MPs, Ø 5,5 m	BBC, DBBC		4-11,5m
2016	Veja Mate	67 MPs, Ø bottom 8,1m; top 6,5m	DBBC	HSD	average 39,3m
2015/16	Sandbank	72 MPs, Ø 6,4-6,8m	BBC, DBBC	HSD	24,5-33,5m
2016	Gode Wind 01 +02	97 MPs, Ø 7,5m	BBC	IHC	max. 34m
2014/15	Amrumbank West	80 MPs, Ø 6m	BBC, DBBC	IHC, HSD	19,5-24m
2014	Borkum Riffgrd 1	77 MPs, Ø 5,9m	BBC	IHC	23-28m
2014	Butendiek	80 MPs, Ø 6 - 6,5m	BBC	IHC	17-22m
2012/14	Nordsee Ost	49 jackets, 4 piles, Ø 2,4m	BBC, DBBC, linear BBC & DBBC		22-25m
2013	Dan Tysk	80 MPs, Ø 6m	BBC, DBBC,TBBC, linear BBC		21-32m
2012/14	Global Tech 1	80 tripods, 3 piles, Ø 2,48m	BBC, linear BBC, DBBC, TBBC		38-40m
2013/14	Baltic 2	80 WTG 39 MPs, Ø 5,2-6,5m 41 jackets, Ø 3m	DBBC, TBBC		23-35m MPs, 35-44m jackets
2011/12	Meerwind Süd/ Ost	80 MPs, Ø 5,5m	DBBC		22-26m

Additionally Small Bubble Curtain (SBC) at Alpha Ventus (2009) and Bard Offshore 1 (3 locations 2010/2011)

OSS foundations up to Ø 2,5m piles used BBC or DBBC in all projects from 2016 on

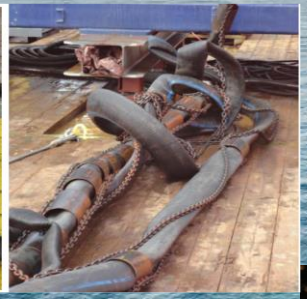
Noise mitigation
- current industry experience/practice

Additional measures & requirements to mitigate noise generation and /or attenuation of generated piling noise for WTG foundation installation since 2015:

- Adjustment of piling method - high frequency & low energy piling
- Online hydrosound monitoring with hammer energy reduction if needed
- Restriction of piling time to e.g. 140 minutes per pile
- Restriction of piling energy to e.g. 1.000 kJ
- BBC re-use limited to e.g. 40 piles (otherwise prove functionality)
- BBC hose length limited to e.g. 800 m
- DBBC deployment time limited to e.g. max 5 days
- Number of BBC compressors limited to e.g. 22 max.

Status Noise mitigation systems

NMS reliability and constrains:



Efficiency monitoring

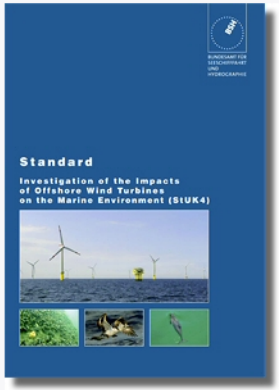
Underwater noise measurements by hydrophones & harbour porpoise abundance by C-POD measurements

Hydro-sound measurement:

- Mobile and stationary hydrophones with data storage
- Online hydro-sound monitoring

Harbour porpoise (CPOD) measurement:

- Mobile and stationary C-PODs with data storage
- Online POD monitoring



Standard

The 3nd update of the German version of the „Standard for Environmental Impact Assessment"

Format: DIN A4 - 86 pages
Year of publication: 2013
BSH-No: 7003

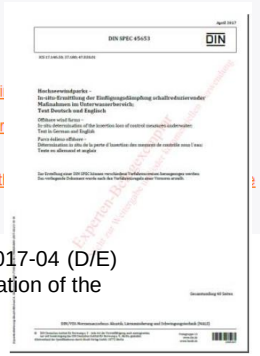
Download (free of charge) (PDF, 1593 KB)

Supplement to table 4.3:

Measuring instruction for underwater sound monitori

Offshore Wind Farms Prediction of Underwater Sour Documentation (PDF, 393 KB)

Offshore Wind Farms - Measuring Specification for t Effectiveness of Noise Control Systems (PDF, 863 KB)



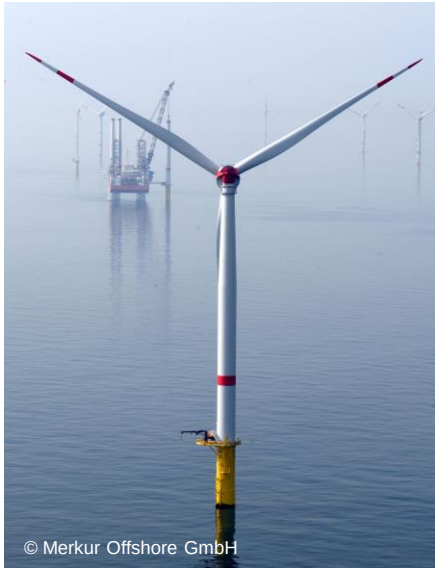
Since April 2017 DIN SPEC 45653:2017-04 (D/E) Offshore wind farms - In-situ determination of the insertion loss of control measures underwater

Current industry experience/practice:

- 1-2 mobile PODs at 750m, 1-2 mobile PODs at 1500m,
- 4-5 single POD stations,
- 1-2 PODs further field (e.g. at POD station and/or nature conservation areas nearby)
- Online POD monitoring occasionally
- 1-2 hydrophones at 750m, 1-2 hydrophones at 1500m and increased effort at reference locations (4-6 positions)
- 1-2 hydrophones further field (e.g. at POD station and/or nature conservation areas nearby)
- Online hydro-sound monitoring in most projects

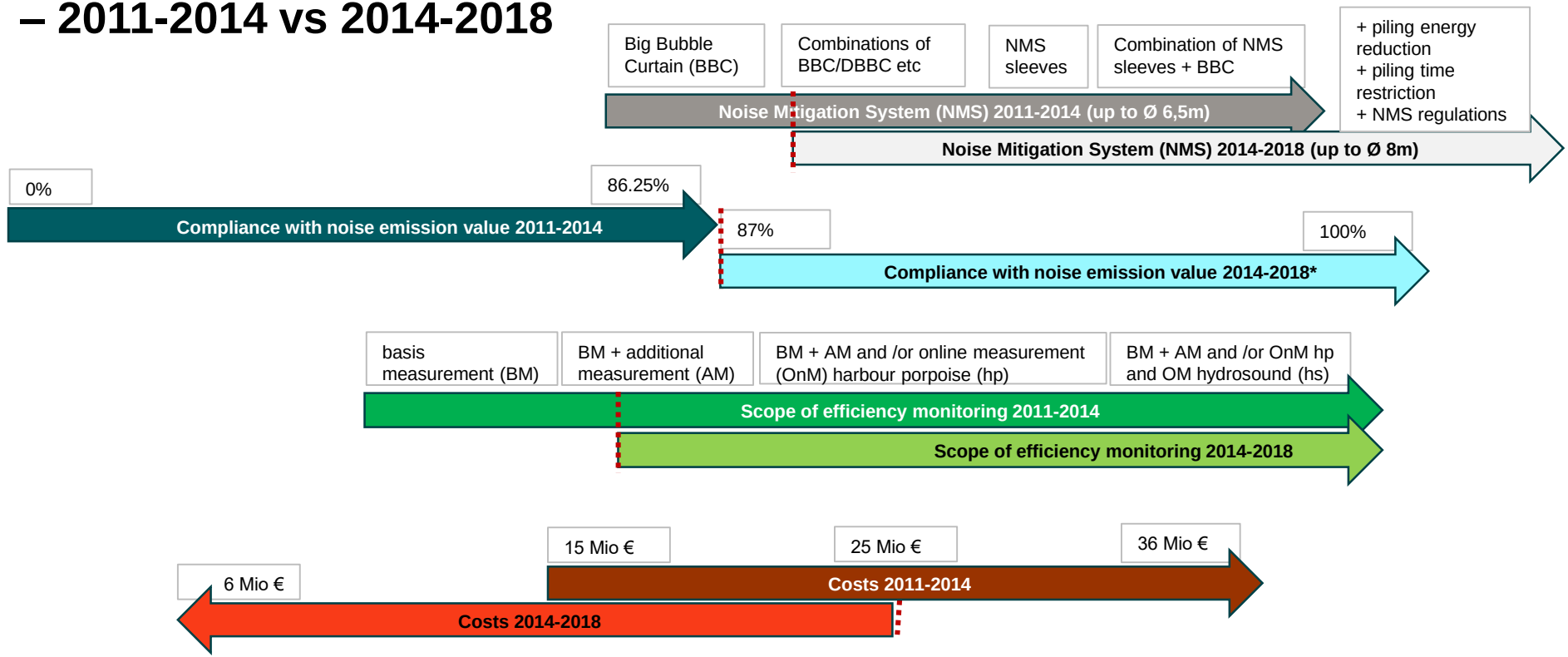
Costs of noise mitigation measures status 2018

- Costs of Noise mitigation systems still range between **6 – 25 Mio EUR,**
- Costs for efficiency monitoring ranges between **200.000€ - 1 Mio EUR**
- **Several additional vessels / vessel- operations:**
  - For noise mitigation/ efficiency monitoring
  - Increased offshore trips / extra barges due to **deck space limitation caused by NMS**
    - Increased costs in case of delays, extra time - cost per day for installation spread range between **250.000 – 350.000 EUR**, plus lost revenue, plus additional costs caused by knock on effects
    - **Increased HSE risks**
    - Increased requirements of **intensive risk assessment** and increased **marine coordination needs**
    - **Increased environmental impact** due to extra disturbance by vessels and fuel use by vessels and compressors



Summary noise mitigation development

– 2011-2014 vs 2014-2018



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NMS noise mitigation 2018:

- <30m water depth with one system 10dB (up to 15dB) with two systems: 15dB
- >30m water – decreasing mitigation efficiency and still a challenge

Summary noise mitigation experience

The results and developments described show the strong commitment of the industry. Noise mitigation however still provides a challenge and technical / logistical constrains need to be taken into account:

- **Installation spread** is fixed 1 year before construction - no possibility to change setup anymore. **Installation sequence** is fixed once manufacturing (~1year before construction) and construction has started.
- **Set of foundations on installation vessel** is 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.
- **High flexibility** for developers in terms of means adopted to meet specific regulations important due to project specific needs
- **Meeting thresholds** is still a challenge and a NMS **adjustment phase** is in most cases needed
- Any Offshore work needs to be planned in detail (method statements) and approved upon with involved parties e.g. authorities, insurance, certifier **- 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.
- **Increased R&D effort** since 2012 with DEPONS, Blue piling, GESCHA I&II …

R&D - GESCHA I+II

- Studying impacts on porpoises in the German bight

About the project

The project evaluates recent data from all OWFs installed between 2010-2016 in the German Bight concerning impacts of underwater noise during foundation installation on harbour porpoises.

Gescha I (finished): Assessment of 7 OWPs built between 2010 and 2013; Link to study: http://www.offshore-stiftung.de/erstmalig-untersucht-rammarbeiten-von-offshore-windparks-haben-keine-negativen-auswirkungen-auf

Gescha II (ongoing): Assessment of 9 additional OWPs built between 2013 and 2016

Value for Wind industry

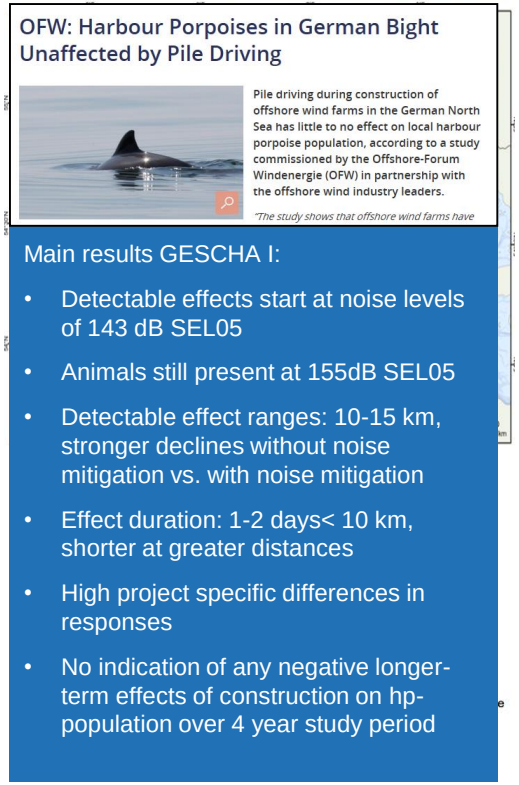
- Better evidence/facts to inform key decisions: Need for deterrents (“seal scarers”), revision of current noise reduction requirements, relevance of piling duration and cumulative effects from parallel construction sites.

Publications:

- Brandt et al. 2018, in press MEPS. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany

Duration: **GESCHA II** 2018-2019

Partners: 21 funding and scientific partners, commissioned by „AG Umweltschutz“ of the Bundesverband der Windparkbetreiber Offshore e.V. (BWO), representing all wind farm developers with projects within the German North Sea



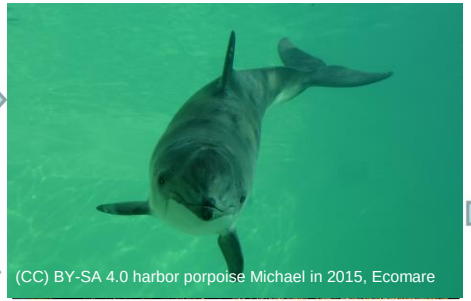
R&D - UW noise frequency based impact & mitigation

Animal reactions to sound are complex – frequency dependent noise reactions and mitigation measures should be taken into account to optimize mitigation

- Response thresholds critically depend on noise frequency, i.e. frequency weighting need to be considered when assessing impacts
- Threshold values based on inverted audiogram frequency weighting functions have lately been revised by NOAA (2016)
- The efficiency of mitigation systems is highly dependent on the type of weighting function applied (Tougaard & Dähne 2017)
- Frequency weighting makes a difference, especially for high frequency marine mammals (e.g.) harbour porpoise, as most NMS such as BBC most effectively attenuate the higher frequencies of piling noise
- So far frequency weighing is only taken into account in the US and UK

Sound
Intensity
Frequency
Repetition rate
Distance to source

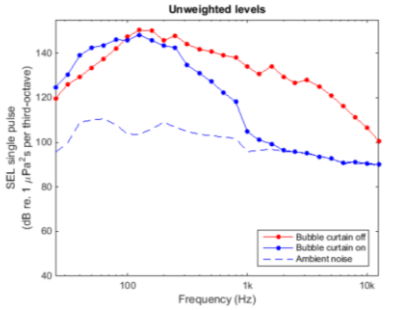
Animal
Behavioural context
Physiological state
Hard-wired responses
Previous experience



Environment
Places to hide
Other threaths
Conspecifics

Response
Ignore
Approach
Reply
Leave
Flee
Startle/panic

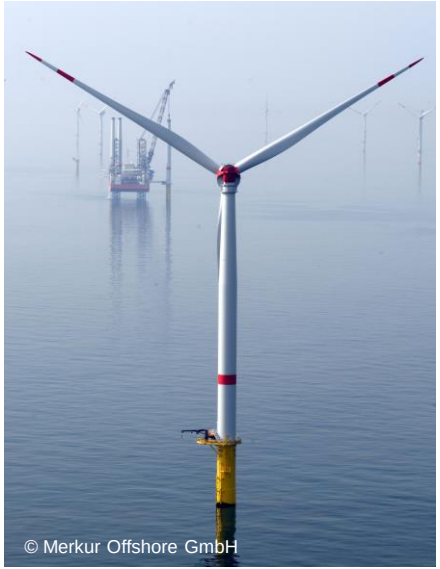
Modified after Tougaard & Nabe-Nielsen 2018



Underwater noise mitigation

Basic consideration:

- Offshore wind energy helps to **achieve government climate change targets**
- 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 e.g. Noise mitigation frequency still mostly neglected
- **Strategic work** towards environmental impact assessment and mitigation regulations should include all stakeholders including industry experience of challenges during offshore installation and operation
- **Cost / benefit** of mitigation measures and renewable energy production should be assessed in an **ecosystem/ holistic approach** i.e. assessing also resource use, disturbance, emissions and increased renewable energy production
- **Early transparency** in regulation is crucial for proper project planning (especially in tender systems!)
- **R&D** to better understand environmental impacts and for new low-impact technologies e.g. alternative installation techniques, is **crucial!**



We aim to assess our actions & impacts from a full ecosystem perspective

By considering the trade-off between local environmental impacts and climate benefits gained from reducing green house gas emissions by replacing fossil energy.

Better evidence → **Less precaution** → **Better decisions**

Thank you for your attention!