

Underwater sound and marine mammals

Framework for assessing ecological and cumulative effects (KEC4.0)

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Framework for assessing ecological and cumulative Effects of offshore wind farms (KEC 4.0)

PRESSURE: Underwater sound

- Main concern: Impact pile driving in the construction phase

Possible concern (not yet considered):

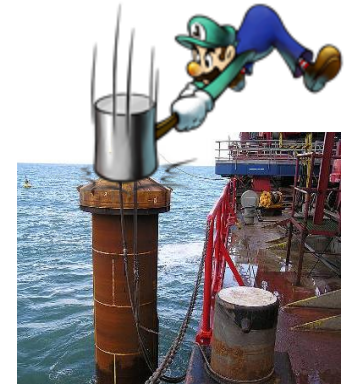
- other underwater sound sources in the construction phase (ships, vibro-piling, etc.)
- underwater sound in the operational phase (turbines & ships)
- underwater sound in the decommissioning phase

EFFECT: Disturbance of aquatic species

- Main concern - marine mammals: harbour porpoise, harbour seal and grey seal

Possible concern (not yet considered):

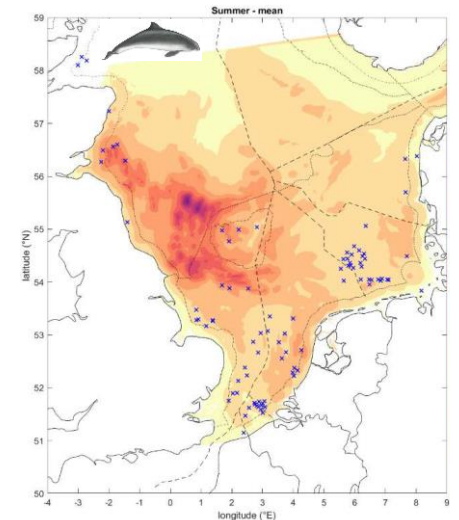
- Fish and invertebrate species



Ecological target for marine mammals

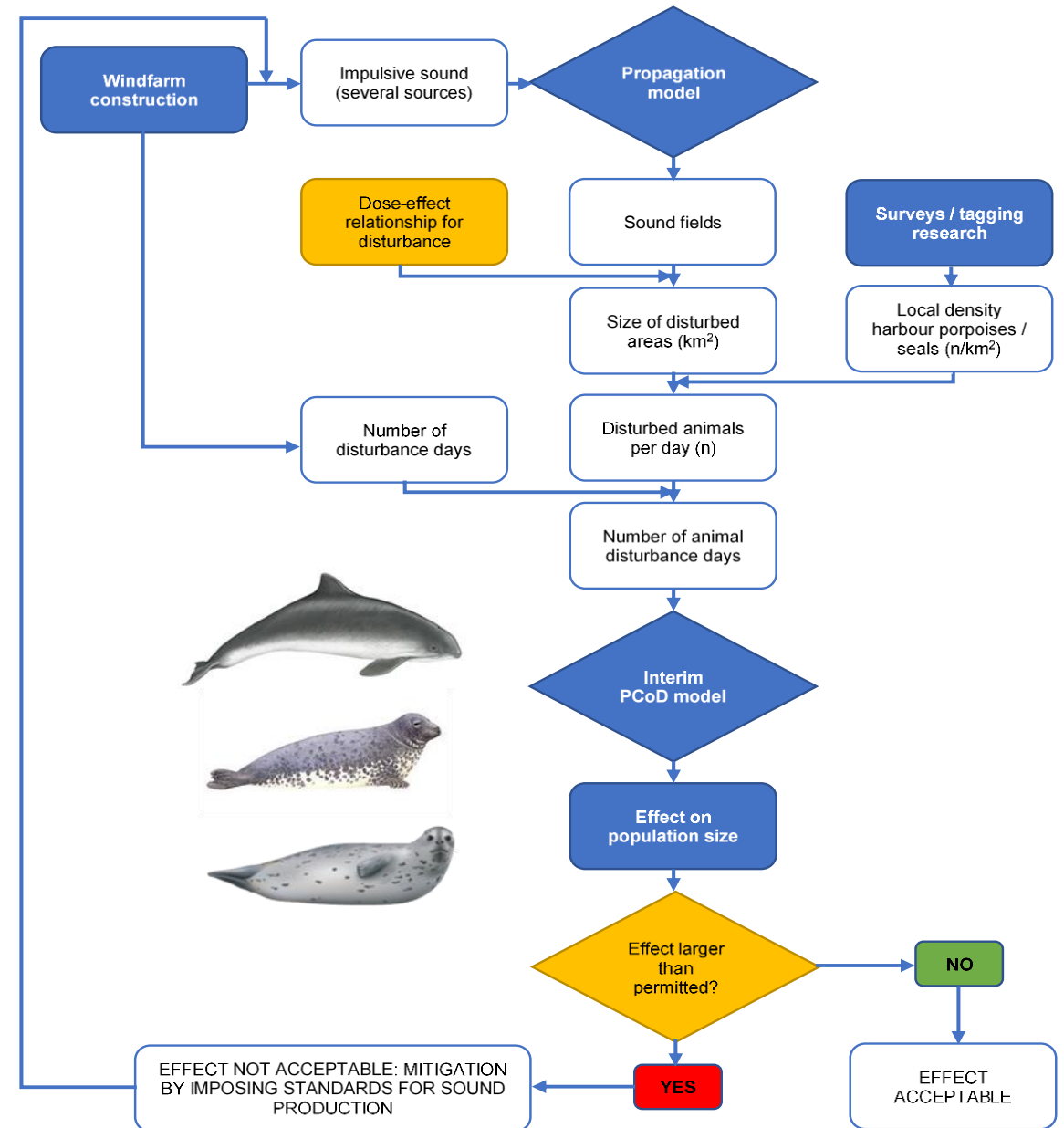
- With the construction of offshore wind farms, the populations of harbour porpoises, harbour seals and grey seals on the Dutch Continental Shelf (DCS) must be maintained at a minimum of 95% of the present level with a high degree of certainty (>95%)
- In other words: *the probability of a population reduction larger than 5% must be smaller than 5%*
- Estimated average population sizes:

Species	North Sea	NCP	5% NCP	source
harbour porpoise	~373,310	~62,771	~3,139	Gilles et al, 2020
harbour seal	~55,418	~18,363	~918	Aarts et al, 2021
grey seal	~19,559	~14,787	~739	Aarts et al, 2021



KEC 4.0 procedure:

1. Calculate underwater sound distribution
2. Use dose-effect relationship and animal density estimate to calculate number of disturbed animals per day
3. Calculate number of 'animal disturbance days'
4. Use the interim PCoD model to estimate the population effect
5. Compare with ecological standard:
high degree of certainty (> 95%) that disturbance by piling sound does not reduce populations with more than 5%



Scenario for North Sea Wind 2016–2030

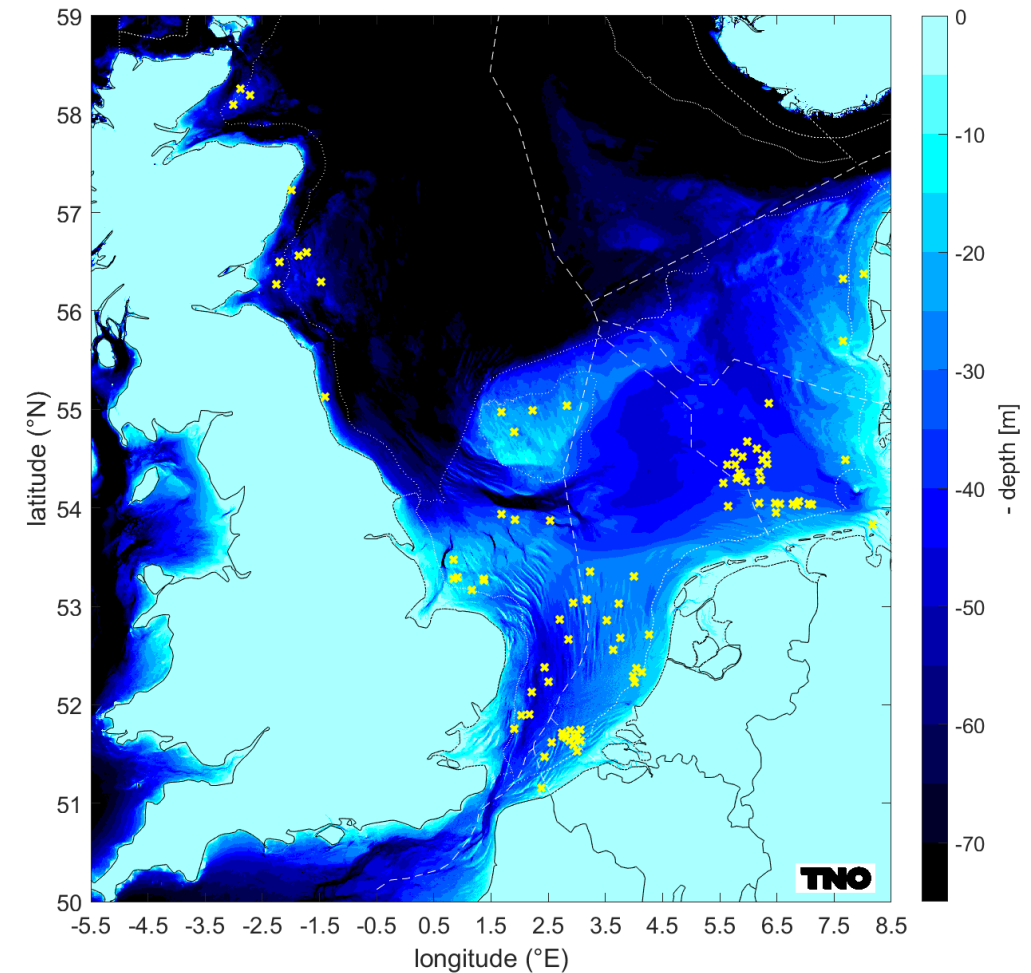
INTERNATIONAL

- 90 wind farms (total 77,5 GW)
- 6,384 turbines (=piling days)

NATIONAL (NL)

- 19 wind farms (maximum variant III: 26,7 GW)
- 1,829 turbines (=piling days)

	jaar	MW	turbines	
Borssele 3	2019	366	39	KEC 1/2
Borssele 4 - Blauwwind	2019	366	39	KEC 1/2
Borssele 1	2020	376	47	KEC 1/2
Borssele 2	2020	376	47	KEC 1/2
Borssele Site V - Two towers	2020	19	2	KEC 1/2
Hollandse Kust Zuid Holland I	2021	385	35	KEC 1/2
Hollandse Kust Zuid Holland II	2021	385	35	KEC 1/2
Hollandse Kust Noord (Tender 2019)	2022	700	69	KEC 1/2
Hollandse Kust Zuid Holland III	2022	385	35	KEC 1/2
Hollandse Kust Zuid Holland IV	2022	385	35	KEC 1/2
Hollandse Kust West - (Tender 2020/2021)	2024	1400	117	KEC 3
Ten noorden van de Waddeneilanden - (Tender 2022)	2026	700	47	KEC 3
IJmuiden Ver	2027	4000	267	KEC 3
Hollandse Kust West zuidelijke punt (= RV I)	2028	700	47	KEC 4
IJmuiden Ver Noord (= RV I)	2028	2000	134	KEC 4
Zoekgebied 5 Oost origineel (= RV I)	2029	4000	267	KEC 4
Zoekgebied 2 Noord (= RV I)	2030	4000	200	KEC 4
Zoekgebied 1 Zuid (+ RV I = RV II)	2030	2000	100	KEC 4
Zoekgebied 1 Noord (+ RV II = RV III)	2030	4000	200	KEC 4



Results



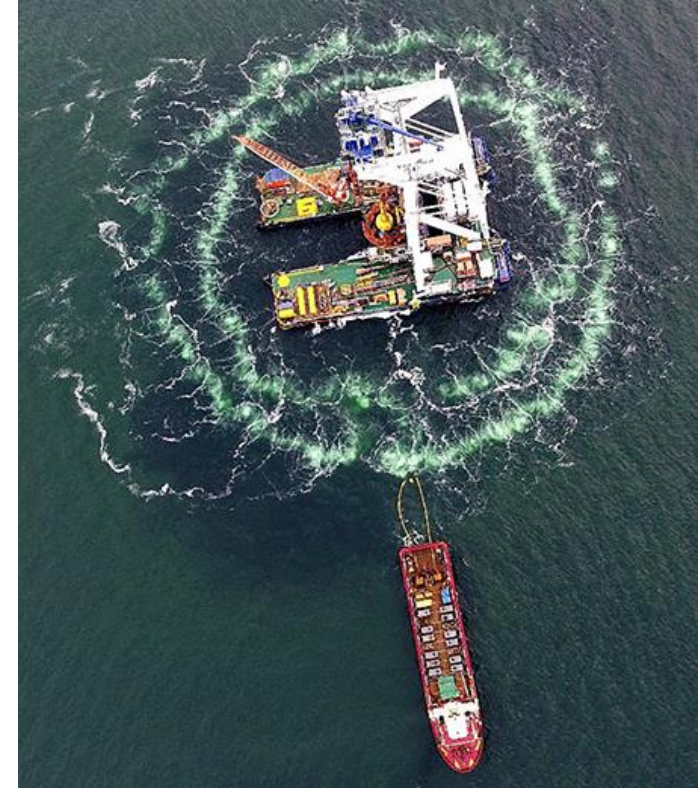
- Risk of piling noise induced **PTS** in porpoises or seals is negligible
- Risk of effects of disturbance by piling noise on NL **seal populations** is negligible
- Risk of effects of disturbance by piling noise on NL **porpoise population** cannot be neglected
- This leads to underwater noise limits in the permits, such as:
the underwater sound from each piling stroke, observed at 750 m from the pile, shall not exceed SELss = 168 dB re 1 μ Pa²s (*broadband, unweighted*).

Noise limits

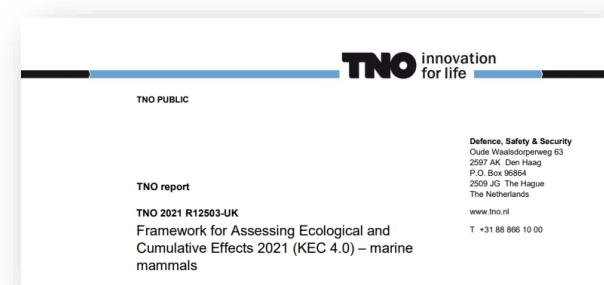
- 2018 – 2022: limits depending on location, season and number of piles
- 2023 – 2026: $SEL_{ss}(750m, broadband, unweighted) = 168 \text{ dB re } 1 \mu Pa^2s$
- After 2026: to be decided
- **KEC 4.0 study** (*large certainty = 5% probability of population reduction*):
 - Installing 16,7 GW between 2016 and 2030 with noise limit **168 dB** may lead to a reduction of the NCP porpoise population with **6.3%**
 - If the noise limit is reduced to **160 dB** from 2027 (Ijmuiden Ver) the population reduction may be limited to **2.9%**

Noise mitigation (impact piling)

- Meet noise limit: SELss(750m,broadband, unweighted)
- OPTIONS:
 - Apply bubble curtains
 - Apply near pile mitigation (HSD, NMS, AdBm)
 - Modify the impact
- CHALLENGE:
 - Noise mitigation is at it limits



KEC 4.0 Conclusions



- Meeting the ecological target for the harbour porpoise population requires a more stringent noise limit than the $SELSS(750\text{ m}) = 168\text{ dB re } 1\text{ }\mu\text{Pa}^2\text{s}$ suggested in KEC 3.0. Other species will benefit from this as well.
- Many knowledge gaps remain, leading to uncertainties in the KEC approach
 - These uncertainties are addressed by worst-case assumptions
 - Hence, the estimated population effects are likely worst-case as well
 - Continued research may help reducing knowledge gaps and uncertainties
- KEC 4.0 is not applicable for alternative piling techniques (e.g. vibro-piling)
 - requires developing new dose-effect relationships (different sound dose)

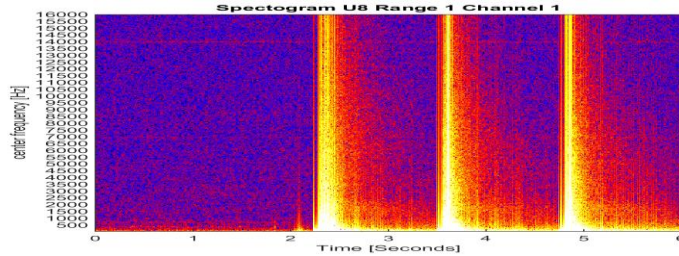
WOZEP: reduce uncertainties in KEC



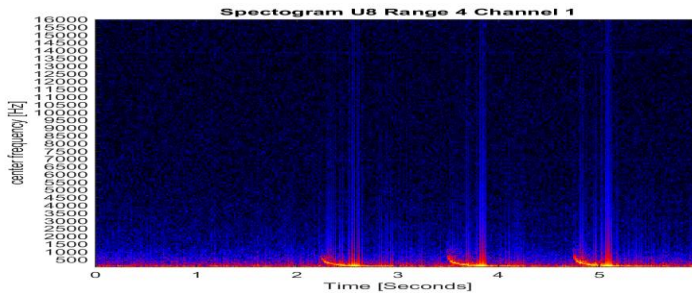
1. Is the unweighted broadband SELs the appropriate dose ?
Should the dose account for frequency sensitivity of porpoise hearing ?
2. Can the assumed dose-effect relationship be experimentally validated ?
⇒ Study data from the construction of Borssele and Gemini wind farms

Piling sound

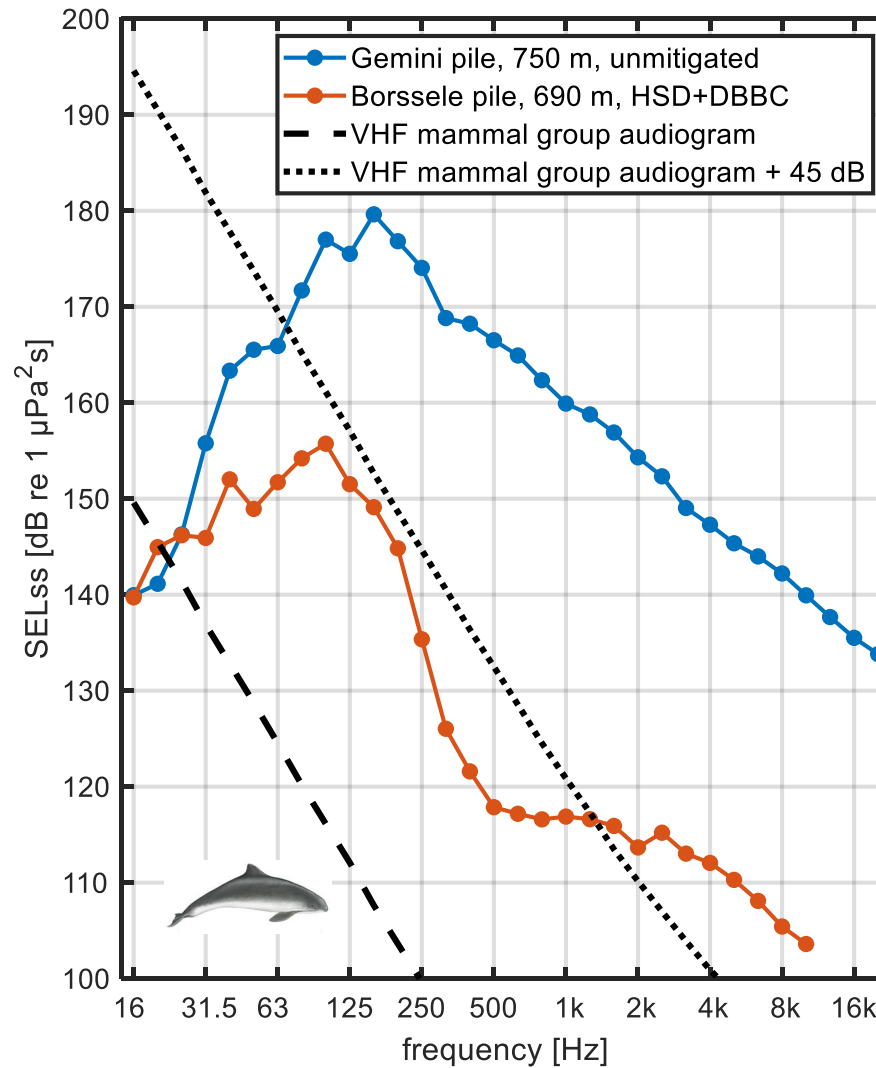
Gemini - 750 m



Gemini - 66 km



Borssele I - 3 km
HSD & DBBC



Conclusions from analysis Gemini/Borssele data

- Mitigation reduces distance at which porpoises avoid marine piling
- KEC impact assessment is conservative, but approach seems appropriate
- Results available at:
 - <https://www.noordzeeloket.nl/functies-gebruik/windenergie/ecologie/wind-zee-ecologisch-programma-wozep/zeezoogdieren/zeezoogdieren-onderwatergeluid-rapporten/>
- See also Wozep News Item:
 - <https://www.noordzeeloket.nl/functies-gebruik/windenergie/ecologie/wind-zee-ecologisch-programma-wozep/newsletter-wozep/wozep-nieuwsflits-januari-2023/welke-onderwatergeluidniveaus-verstoren/>

