

Mitigation measures to prevent noise-induced injury to harbor porpoises (*Phocoena phocoena*)

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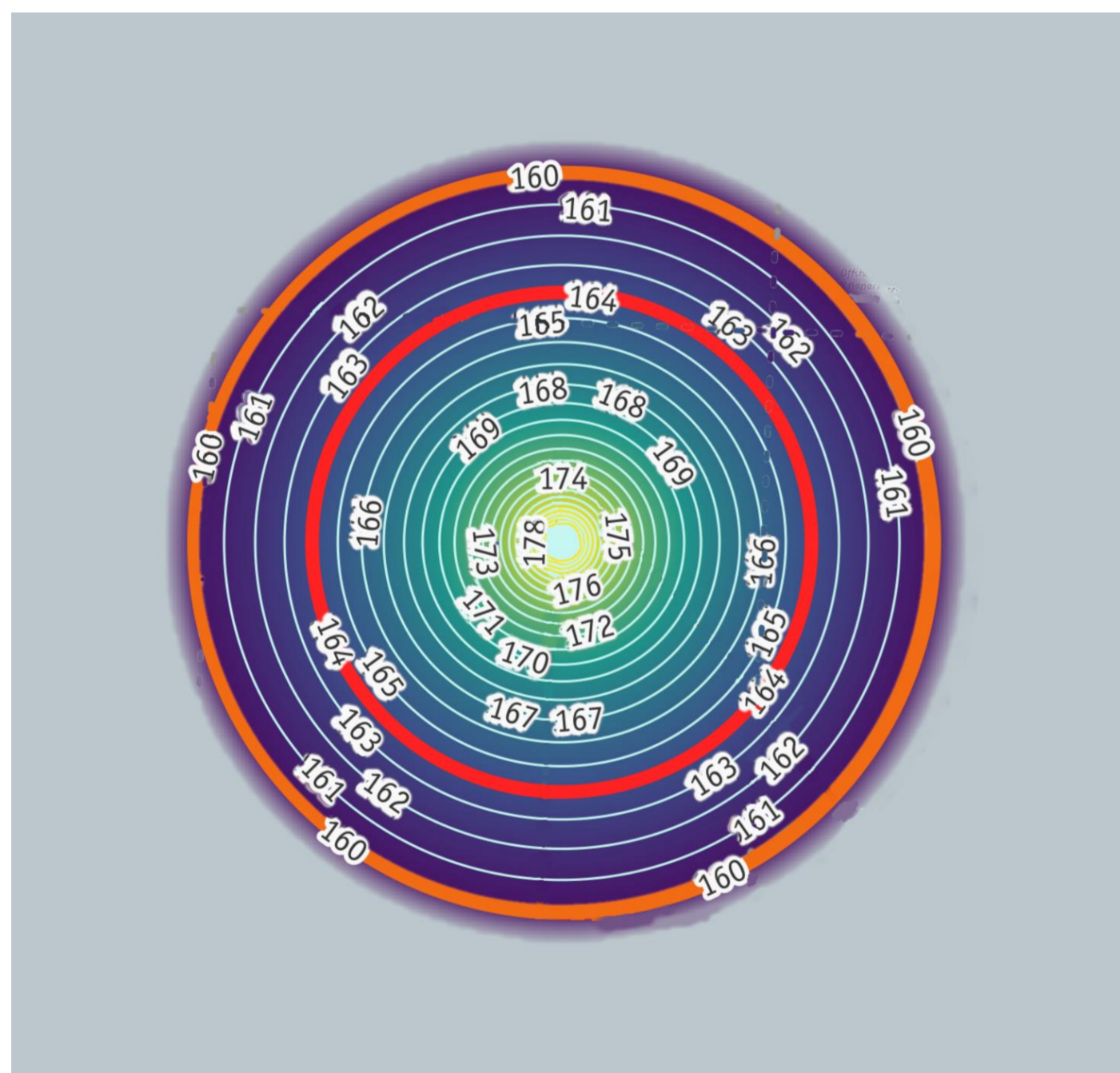
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In the aftermath of World War II, military operations and subsequent dumping have left approximately **1.6 million tons of conventional munitions and 5,000 tons of chemical warfare agents left in the German North and Baltic Seas**. These unexploded ordnances (UXOs) pose a significant threat to human safety, the environment and infrastructure, particularly during offshore construction work, since a significant number of these UXOs still possess explosive potential. If UXOs cannot be transported to land for disposal, offshore detonations are conducted. In order to minimize the negative impact of noise emissions on harbor porpoises during an UXO clearance, the following measures are currently being implemented in the German Exclusive Economic Zone (EEZ).

Months before...

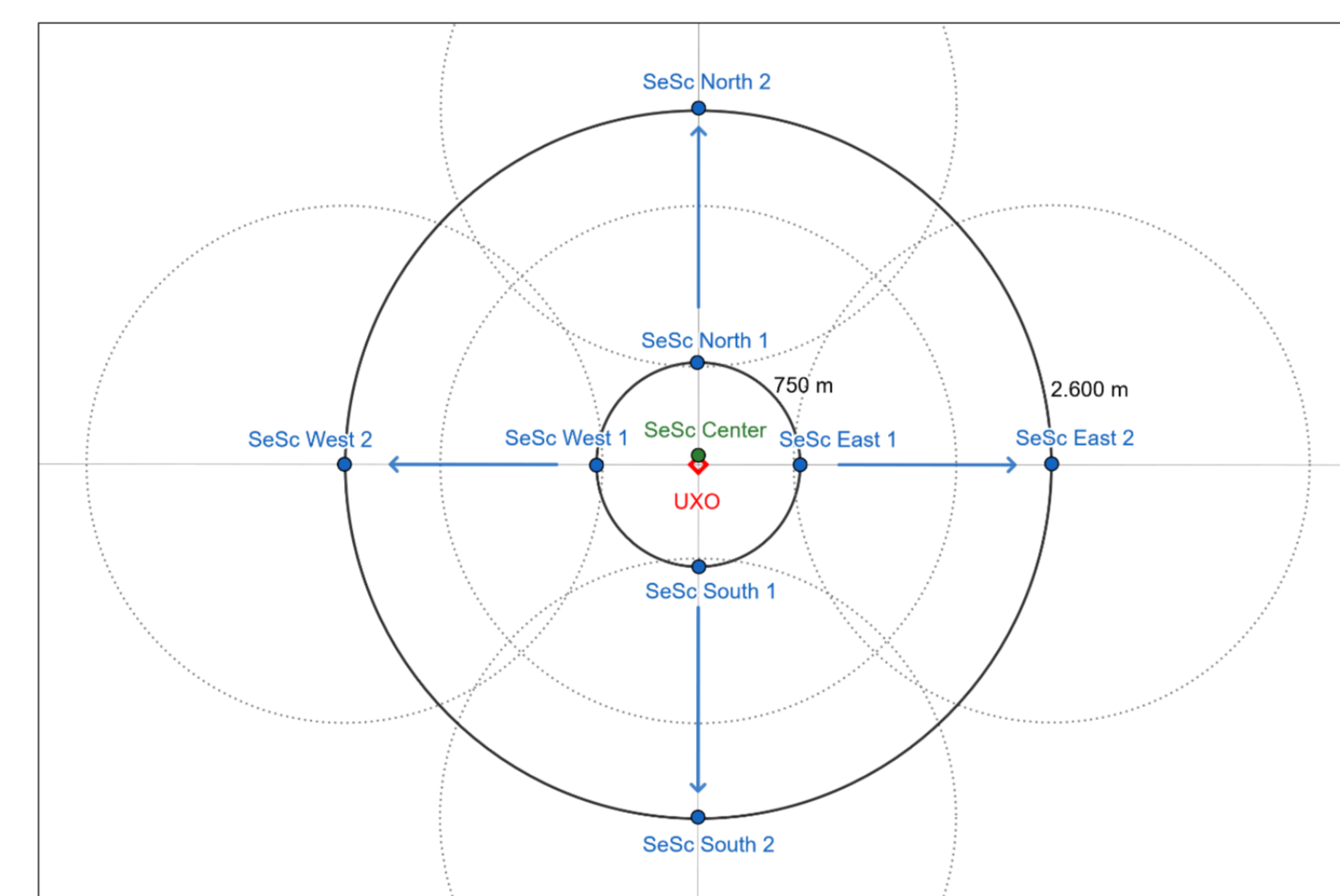
- Preparation of noise forecasts based on UXO netto explosion mass and containing explosives + ignition charge
- Preparation of measurement concept for underwater noise
- Preparation of deterrence concept
- The deterrence has to cover the radius of ≥ 160 dB (broadband)
- UXO clearance and pile driving activities in the same EEZ should not take place at the same time



Noise forecast for an UXO detonation (source: itap GmbH).

Right before...

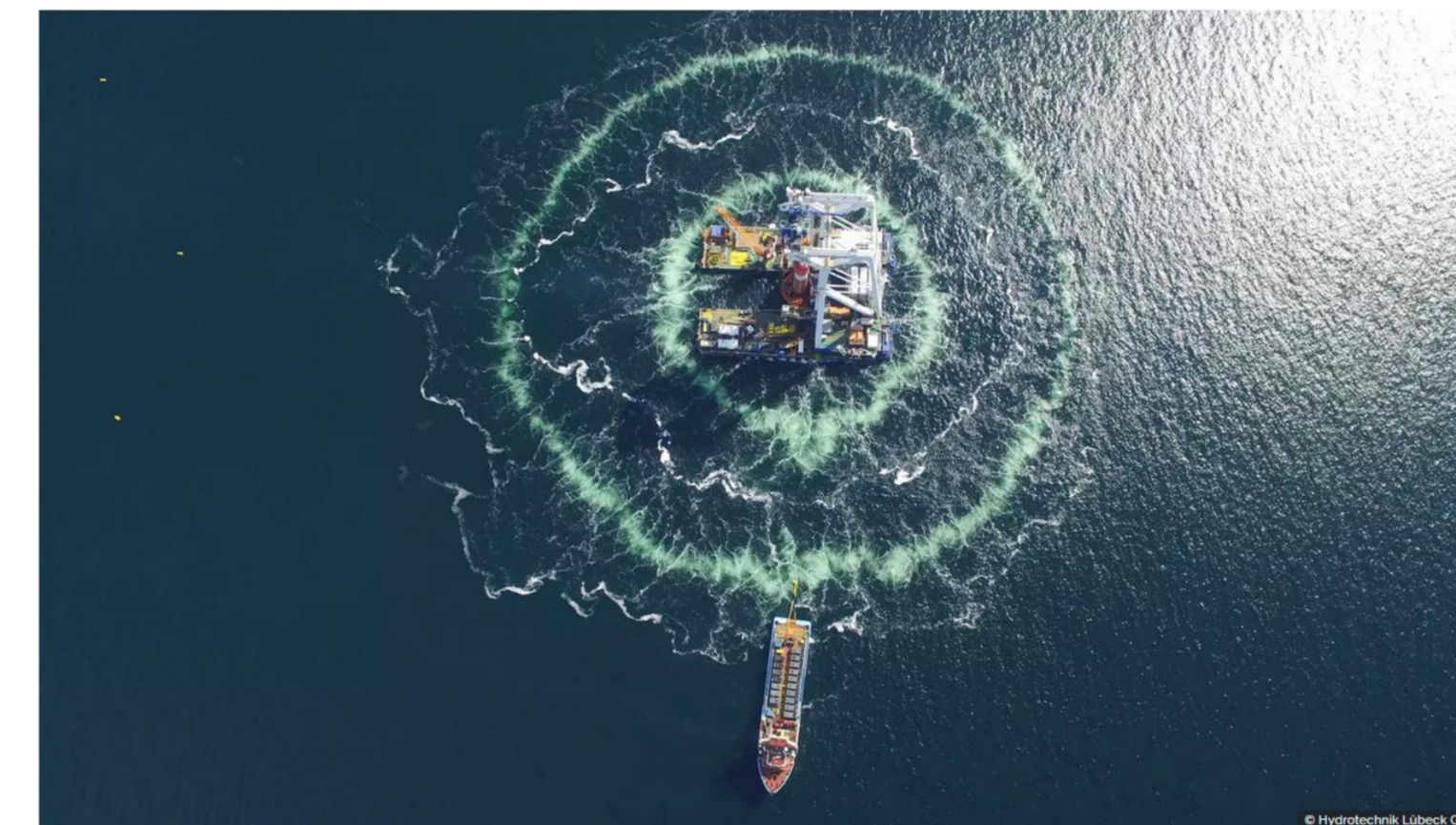
- Deterrence of harbor porpoises from the UXO location: at least 4 guard vessels deploying different harrassment devices (pinger, APD and AHD)
- Time-staggered deployment of devices
- Vessels start from center and move outwards



Deterrence procedure right before detonation.

During...

- Bubble curtain system used to mitigate noise exposure during UXO clearance



Deployed Double Big Bubble Curtain. Brighter parts show air bubbles of the curtain surfacing (source: Hydrotechnik Lübeck).

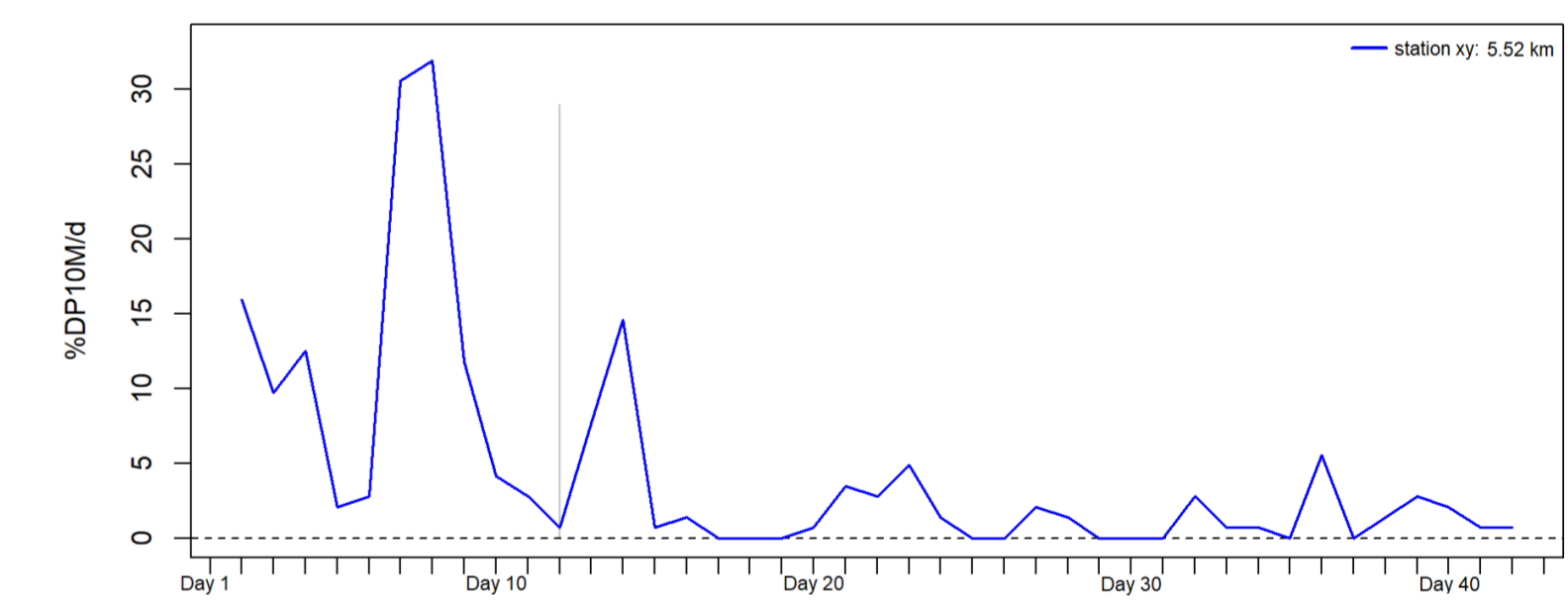
- Measurement devices in several distances (hydrophones for sound measurements + C-PODs/F-PODs for monitoring harbor porpoise presence)



C-PODs record presence and absence of harbor porpoises.

After...

- Bringing the different strings together:
- How effective was the deterrent method?
- How loud was the detonation and at what distance?
- Could harbor porpoises have been harmed?
- Is an effect detectable in long-term data?
- Is an effect detectable at greater distances over a longer period of time?



Long-term data in greater distance before and after an offshore detonation.

Experiences so far:

- Every UXO clearance is different and requires different configurations for noise reduction and deterrence.
- Previous projects have shown that effective deterrence can reduce harbor porpoise detection rates in a radius of dangerously high noise exposure to zero. Nevertheless, a detection rate of zero doesn't necessarily mean an absence of harbor porpoises. Due to these uncertainties, expanding the methods in upcoming projects with e. g. drone footage is conceivable.
- Some projects have shown reduction in detection rates of harbor porpoises before, during and after the explosion up to great distances.
- It is unclear what proportion of this effect is due to (1) the blasting itself, (2) the deterrence, and (3) the high level of shipping traffic caused by the project.
- Some projects have demonstrated an increase in detection rates immediately following a detonation in close proximity. It is assumed that harbor porpoise prey on dead fish after the detonation, which is thought to be unlikely for harbor porpoises. This questions will be part of upcoming projects.

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