ECS-ASCOBANS Workshop: Towards meaningful conservation action for Risso's dolphins in the North Atlantic

Underwater noise

Dr Nienke van Geel

20-04-2026

Vocalisations & Hearing

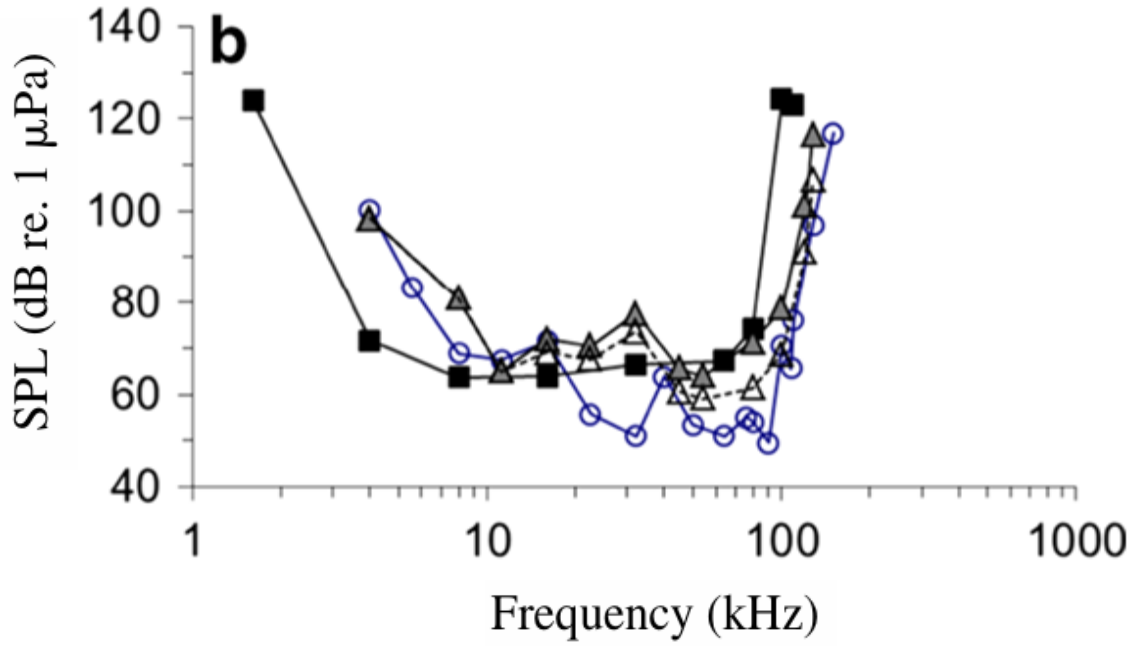
RDs produce a range of **vocalisations**, including:

Echolocation: ~15-200 kHz, with peak frequency of 45 kHz and geographical variability (Madsen et al., 2004; Soldevilla et al., 2010 & 2017; Webber et al, in review)

Whistles: 4-22 kHz (Corkeron & Van Parijs, 2001)

Grunts: as low as 0.4 kHz (Corkeron & Van Parijs, 2001)

Hearing capability: ~1-130 kHz;
Highest sensitivity ~10-80 kHz (n=3)

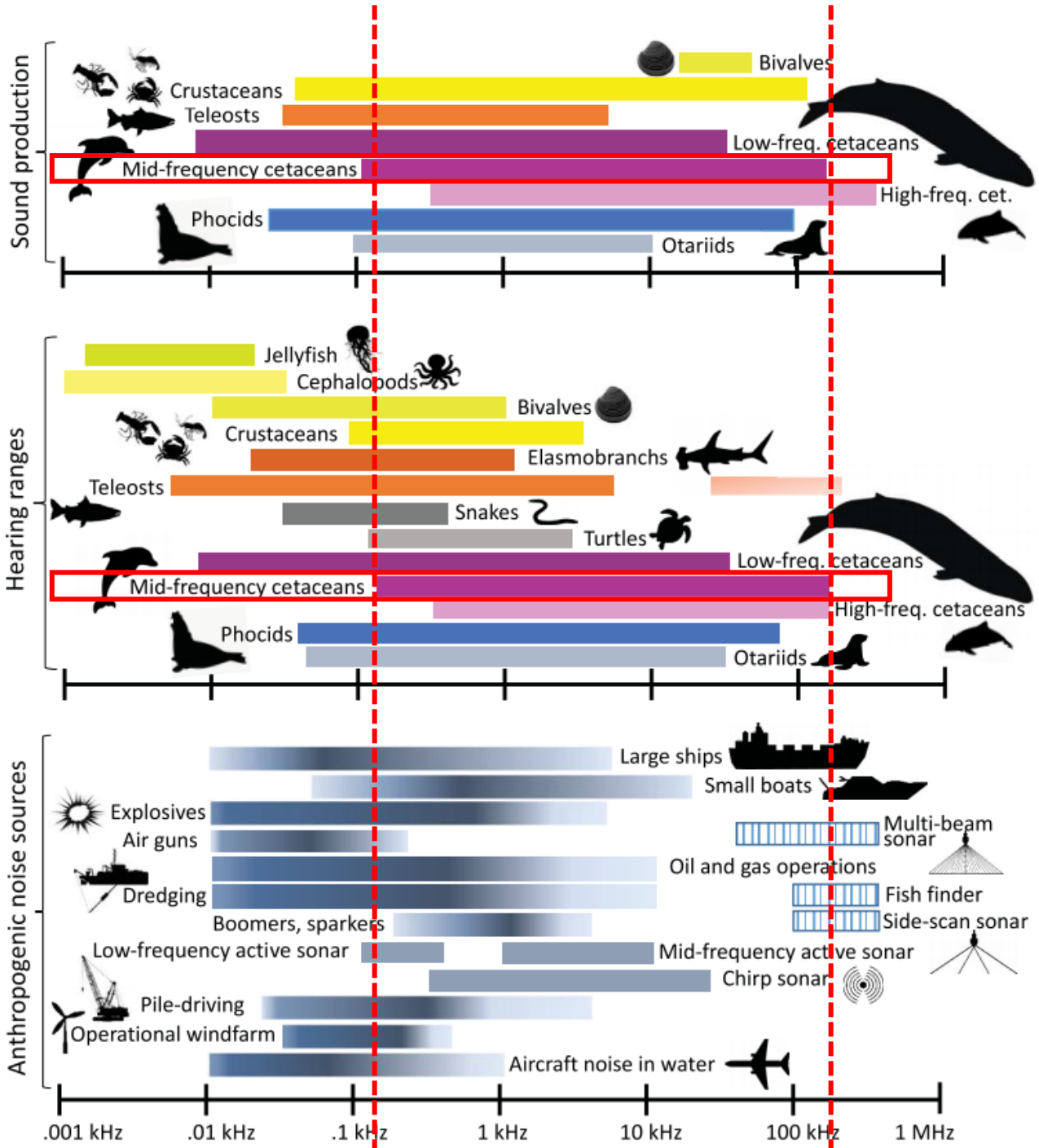


(Mooney et al., 2015, incl. Nachtigal et al., 1995 & 2005)

Anthropogenic underwater noise

Noise impacts

- Behaviour (disturbance)
- Temporary hearing damage
- Permanent hearing damage
- Mortality



(Duarte et al., 2021)

Noise sources

Table 10.4 Noise source categorization scheme (Erbe et al., 2025)

Noise category	Noise sources
Impulsive	Airgun, airgun array, boomer, explosion, firecracker, impact piling, rifle, terrestrial seismic survey, seismic survey vessel, sparker
Continuous	Construction, dredging, drilling, icebreaking, fixed-wing aircraft, rotary-wing aircraft, land vehicle, naval missile, outboard motor, vibratory piling, whale-watching vessel, ship(s) (nearby), shipping (distant), snow vehicle, tidal turbine, unmanned aerial vehicle, vessel(s)
Natural	Ambient noise, brown noise, killer whale sounds, psychophysiological model, social vocalizations, white noise, wind
Tonals/ sweeps	Acoustic Communication network for Monitoring of underwater Environment (ACME), acoustic deterrent devices (ADDs), M-sequences, pulses (continuous wave), sweeps (frequency-modulated), tonals → Includes acoustic anti-fouling
Sonar	Continuous low-frequency active sonar (CLFA), high-frequency sonar (HFS), echosounders, low-frequency active sonar (LFA) (US: <1 kHz; UK: 1–2 kHz), mid-frequency sonar (MFS) (US: 1–10 kHz; UK: >2 kHz)

Continuous noise

Assessment: Typically based on modelling vessel-type specific noise outputs from AIS data & may be validated by measurements from *in-situ* acoustic recordings

(Farcas et al., 2020)

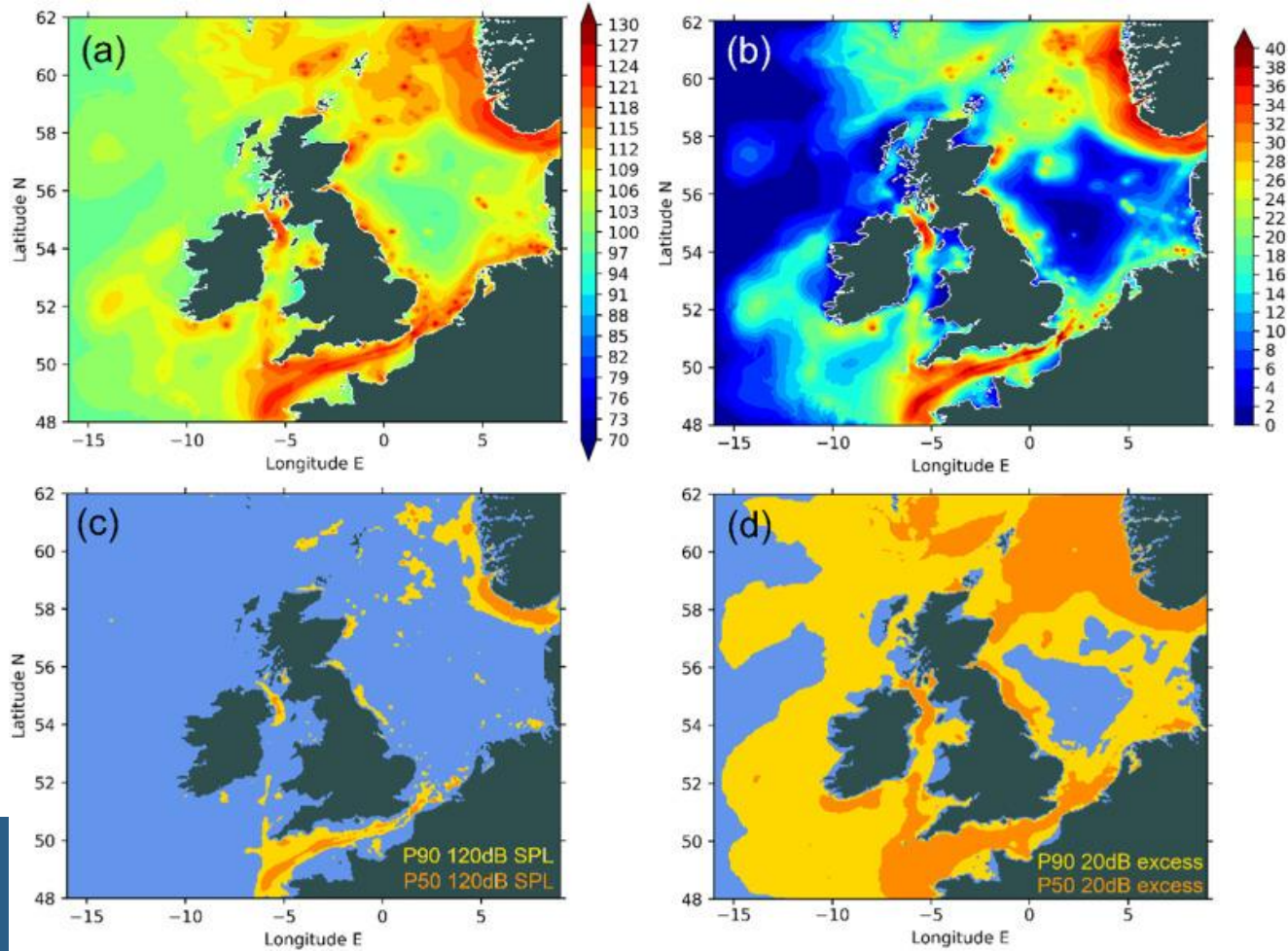
A: Median ship & wind noise map 2017 63-4,000 Hz

B: Annual median ship noise excess

C: Areas with broadband noise level >120 dB for 50% (P50) and 10% (P10) of the year

D: Areas with ship noise excess >20 dB for 50 & 10% of the year

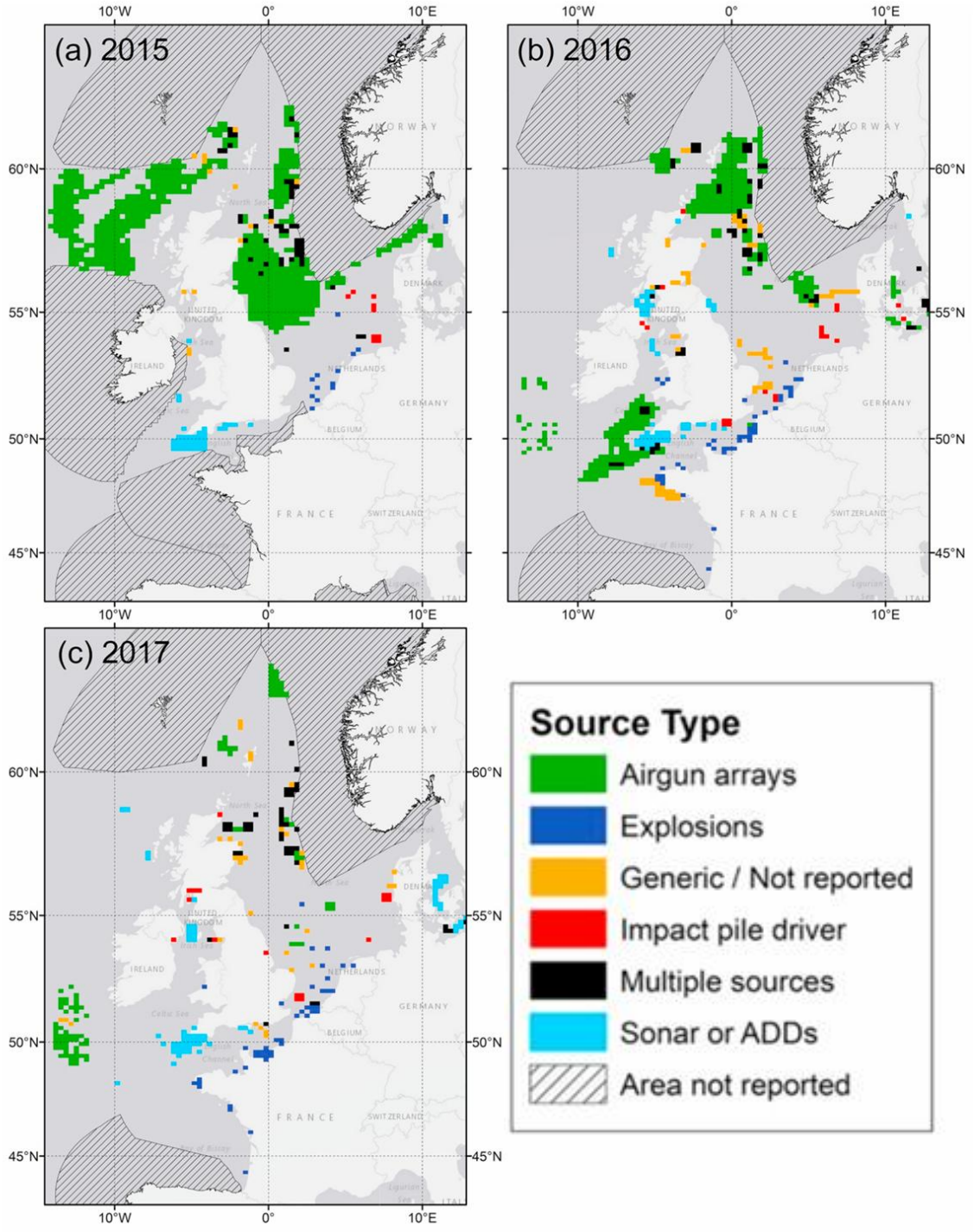
→ Can be adjusted to specific frequency bands, as well as monthly overviews



Impulsive noise

Impulsive noise activities in the NE Atlantic are reported to the Impulsive Noise Register (INR; established under OSPAR & maintained by ICES)

→ Info on type of activity, spatial extent & duration



(Merchant et al., 2020)

Auditory injury & behaviour response onset criteria – HF cetaceans

Impact zones based on noise propagation modelling (& frequency-weighting)

Auditory injury (NOAA/NMFS, 2024; Southall et al., 2019)

	Non-impulsive sounds	Impulsive noise	
	Weighted SEL_{24h} (dB re 1 µPa^2s)	Peak SPL (dB re 1 µPa)	Weighted SEL_{24h} (dB re 1 µPa^2s)
• Temporal hearing damage:	181	170	224
• Permanent hearing damage:	201	230	193 / 185

Behavioural impact (NMFS, 2005)

- Continuous sources: 160 dB re 1 µPa
- Intermittent, non-continuous sources: 120 dB re 1 µPa

→ **BUT** very context-specific

Noise impact studies

Military sonar

- **Henderson et al. (2014):** Behavioural responses of free-ranging RD groups to incidental MFAS in the Southern California Bight. A total of 3 encounters coincided with sonar activity. For these, **no changes** were reported in behavioural state, direction of travel, vocalisation rate, and call level.
- **SOCAL-BRS study** (+ 3S/3S^2): Using D-tags to assess impacts of MFAS on RD behaviour. **Results not public?**

(From: Visser, 2015)

Seismic surveys

- **Stone et al. (2017):** Based on 81 RD encounters, detection rates & closest distance of approach during airgun activity in the UK during firing **did not significantly differ** compared to non-firing

References (in order of appearance)

Madsen et al. (2004) Echolocation clicks of two free-ranging, oceanic delphinids with different food preferences: false killer whales *Pseudorca crassidens* and Risso's dolphins *Grampus griseus*. Doi: 10.1242/jeb.00966.

Soldevilla et al. (2010) Spatial and temporal patterns of Risso's dolphin echolocation in the Southern California Bight. Doi: 10.1121/1.3257586.

Soldevilla et al. (2017) Geographic variation in Risso's dolphin echolocation click spectra. Doi: 10.1121/1.4996002.

Webber et al. (in review) Characteristisation of Risso's dolphin (*Grampus griseus*) echolocation clicks from the Northeast Atlantic.

Corkeron & Van Parijs (2001) Vocalizations of east ern Australian Risso's dolphins, Grampus griseus. Doi: 10.1139/z00-180.

Mooney et al. (2015) Hearing abilities and sound reception of broadband sounds in an adult Risso's dolphin (*Grampus griseus*). Doi:10.1007/s00359-015-1011-x.

Nachtigall et al. (1995) Risso's dolphin (*Grampus griseus*) hearing thresholds in Kaneohe Bay, Hawaii. In: Sensory systems of aquatic mammals: pp 49–53.

Nachtigall et al.(2005) Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. Doi:10.1242/jeb.01876.

Duarte et al. (2021) The soundscape of the Anthropocene ocean. Doi: 10.1126/science.aba4658.

Erbe et al. (2025) Behavioral responses to underwater noise. In: Marine Mammal Acoustics in a Noisy Ocean: pp 611-698.

Farcas et al. (2020) Validated shipping noise maps of the Northeast Atlantic. Doi: 10.1016/j.scitotenv.2020.139509.

Merchant et al. (2020) Impulsive noise pollution in the Northeast Atlantic: Reported activity during 2015–2017. Doi: 10.1016/j.marpolbul.2020.110951.

NOAA/NMFS (2024) 2024 Update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 3.0). Underwater and in-air criteria for onset of auditory injury and temporal threshold shift. Available at: https://www.fisheries.noaa.gov/s3/2024-11/Tech_Memo-Guidance_-3.0-_OCT-2024-508_OPR1.pdf.

Southall et al. (2019) Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. Doi: 10.1578/AM.45.2.2019.125.

Henderson et al. (2014) Delphinid behavioural responses to incidental mid-frequency active sonar. Doi: 10.1121/1.4895681.

Visser (2015) Cetacean social behavioral response to sonar exposure. Available at: https://apps.dtic.mil/sti/html/tr/AD1014335/index.html.

Stone et al. (2017) The effect of seismic operations in UK waters: Analysis of Marine Mammal Observer data. J. Cetacean Res. Manage. 16: 71–85.