Saturn
Developing Solutions for Underwater Radiated Noise

SATURN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101006443.

Marine mammals and vessel noise: Exposure, impacts and potential solutions

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DOSITS webinar, 27.09.2023

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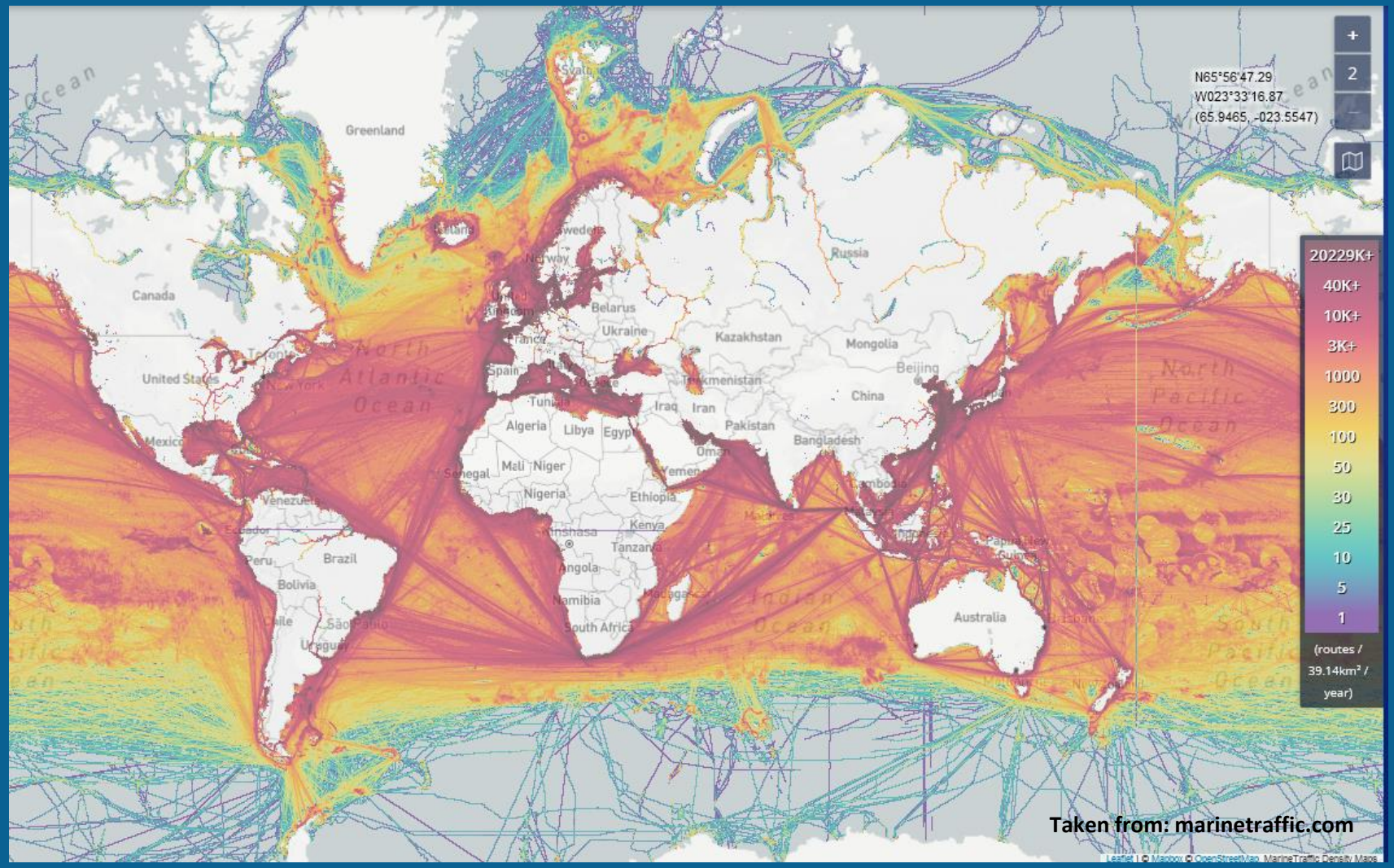


Introduction

Ships continuously produce underwater radiated noise

- Main sources: propeller (cavitation!) and machinery
- Most energy at low frequencies (<200 Hz), BUT can be broadband and extend to higher frequencies
- Vessel noise characteristics depend on many different factors and what is received by an animal depend on sound propagation conditions

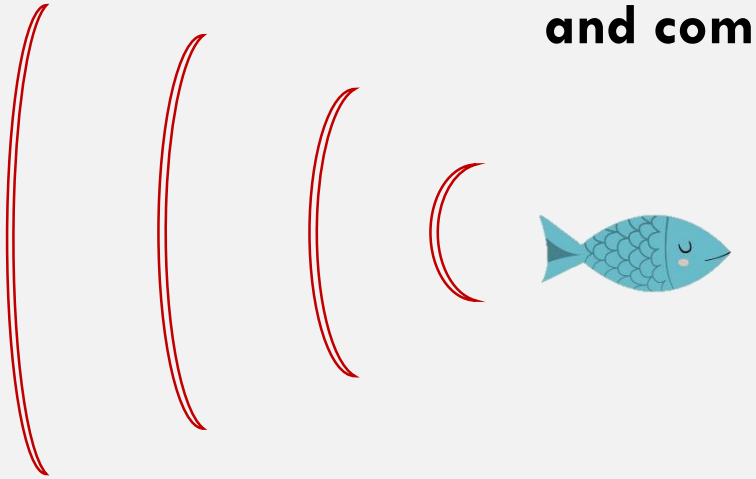
Introduction

Marine mammals use hearing as primary sense to detect predators/prey, orientate and communicate with conspecifics

Click

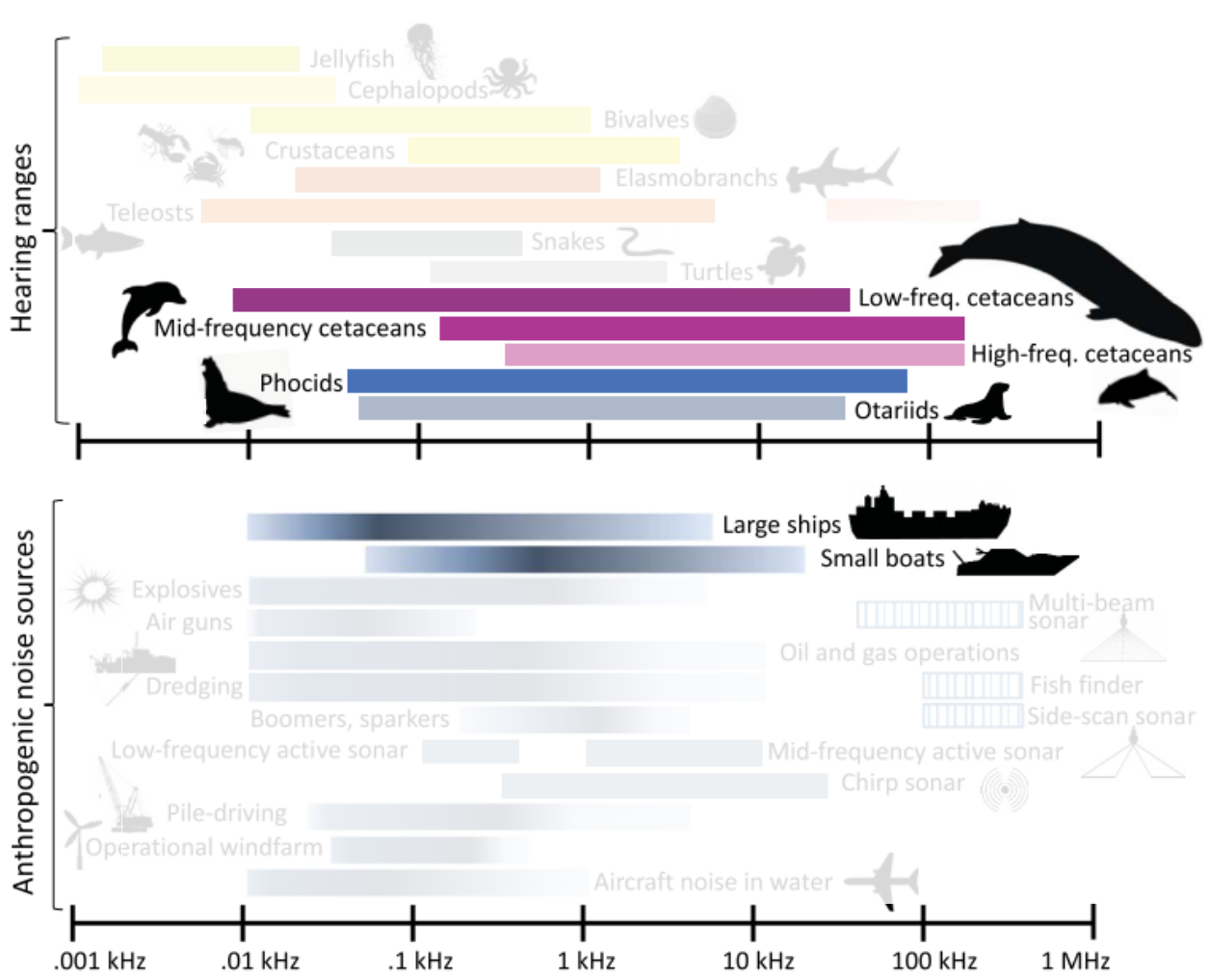
Introduction

Marine mammals use hearing as primary sense to detect predators/prey, orientate and communicate with conspecifics



Echo

Introduction



Marine mammals use hearing as primary sense to detect predators/prey, orientate and communicate with conspecifics

Vessel noise is audible to marine mammals

Duarte et al. 2021

What are the effects of vessel noise on marine mammals and how can we measure them?

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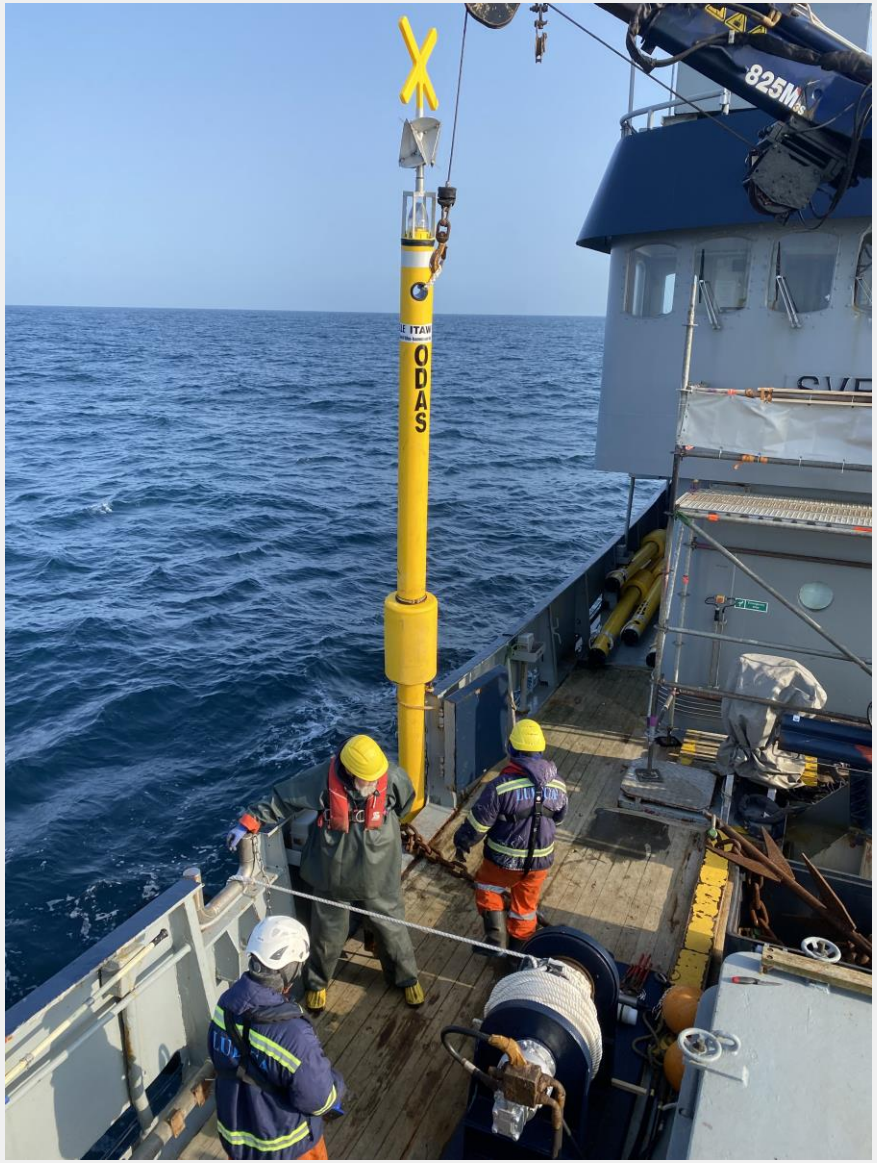
Approaches to measure exposure and impacts of shipping noise on marine mammals

1. Passive acoustic monitoring (PAM)
2. Risk maps
3. Association of vessel movements with individual animal movements
4. Deployment of sound and movement biologging tags

1. Passive Acoustic Monitoring (PAM)

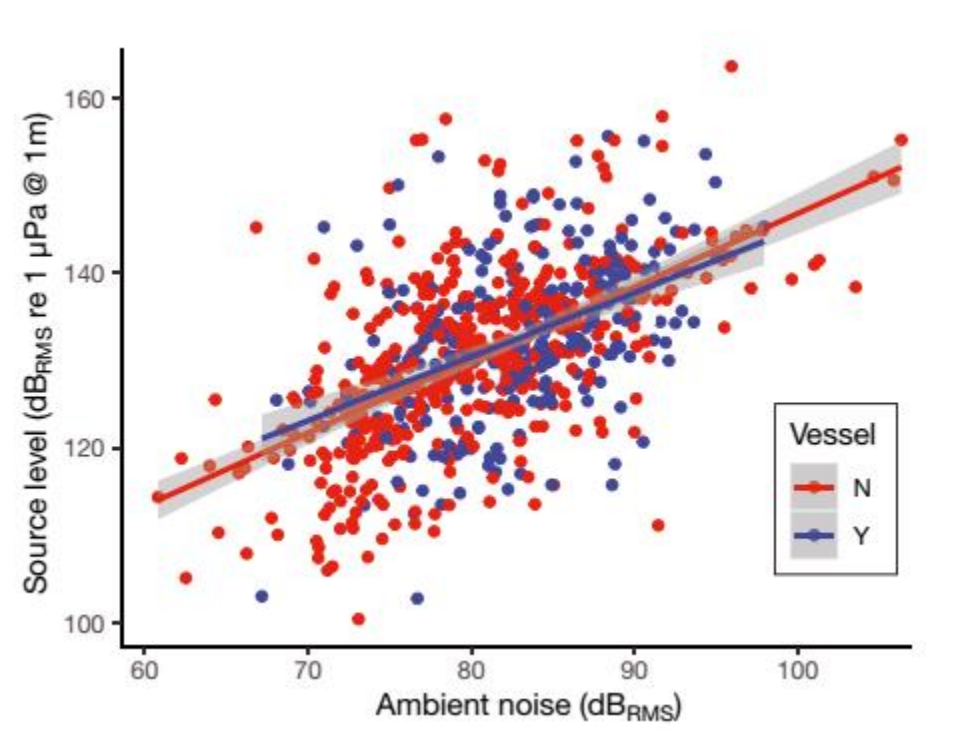
Deployment of sound recorders in an area of interest

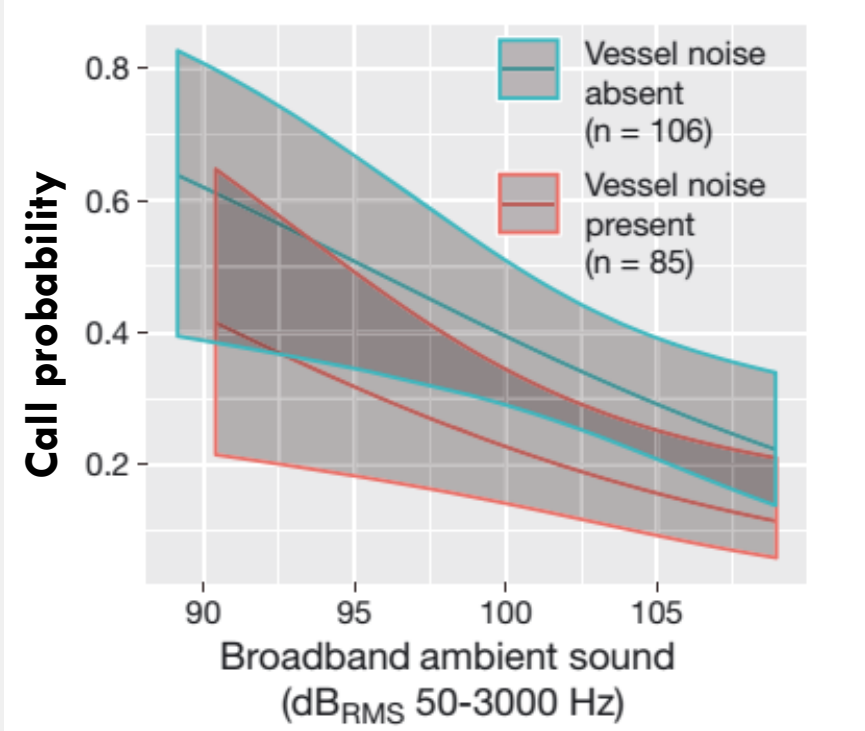


Photos: Johannes Baltzer

1. Passive Acoustic Monitoring (PAM)

Example: Humpback whales (*Megaptera novaeangliae*) alter their calling behaviour due to vessels



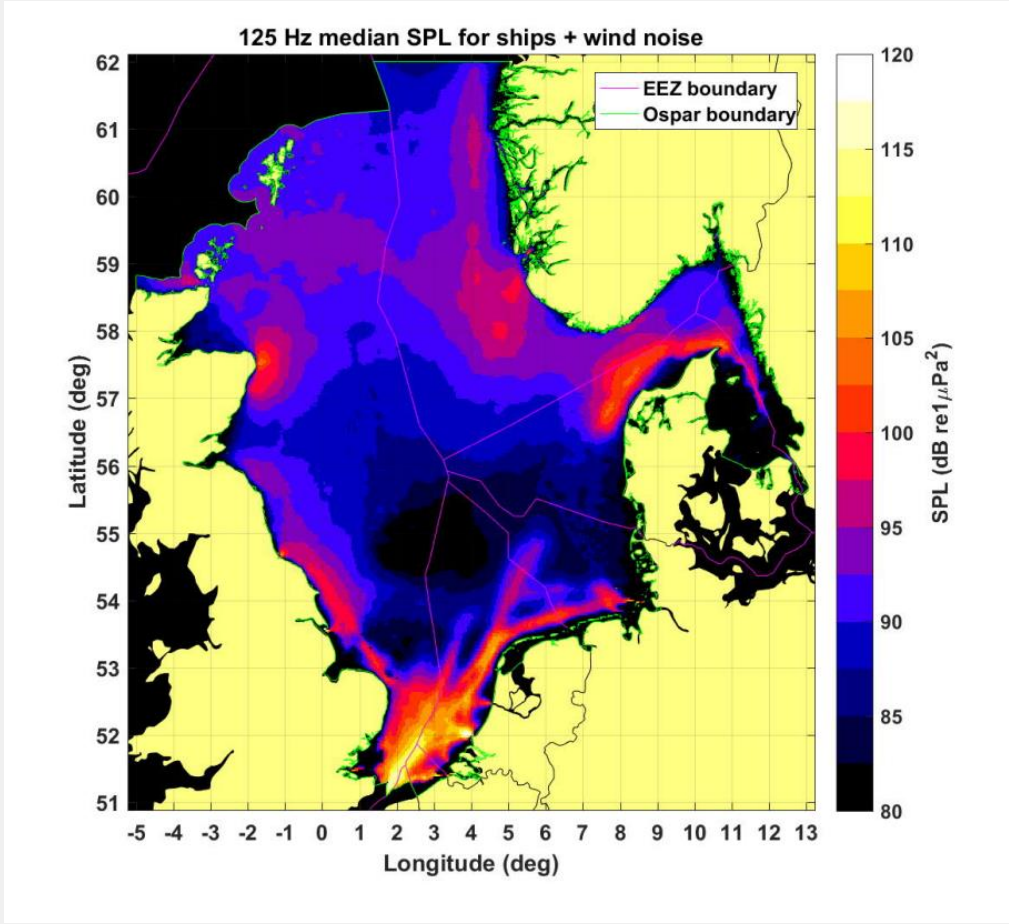


Fournet et al. 2018

2. Risk maps

- Assessing spatial overlap between a given stressor (e.g. underwater radiated noise) and species distribution

- Result: Risk map which shows an overlap between species occurrence and presence/absence/gradient of a given stressor

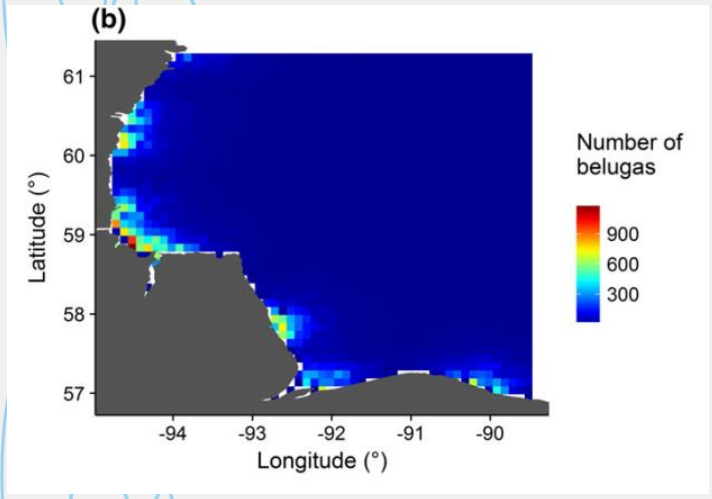


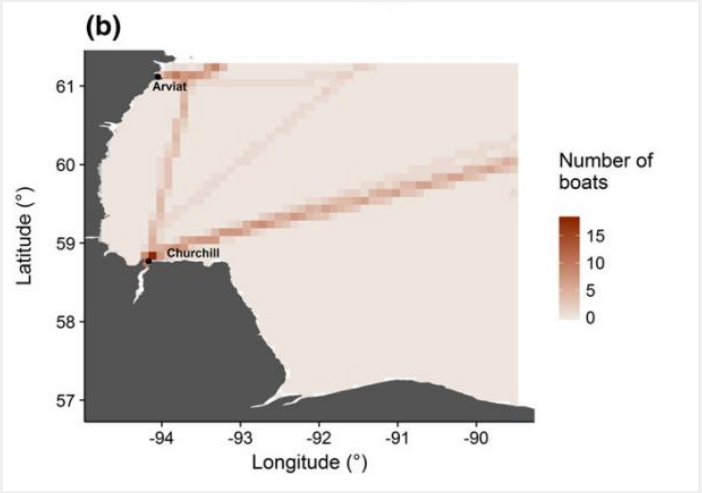
Output from JOMOPANS

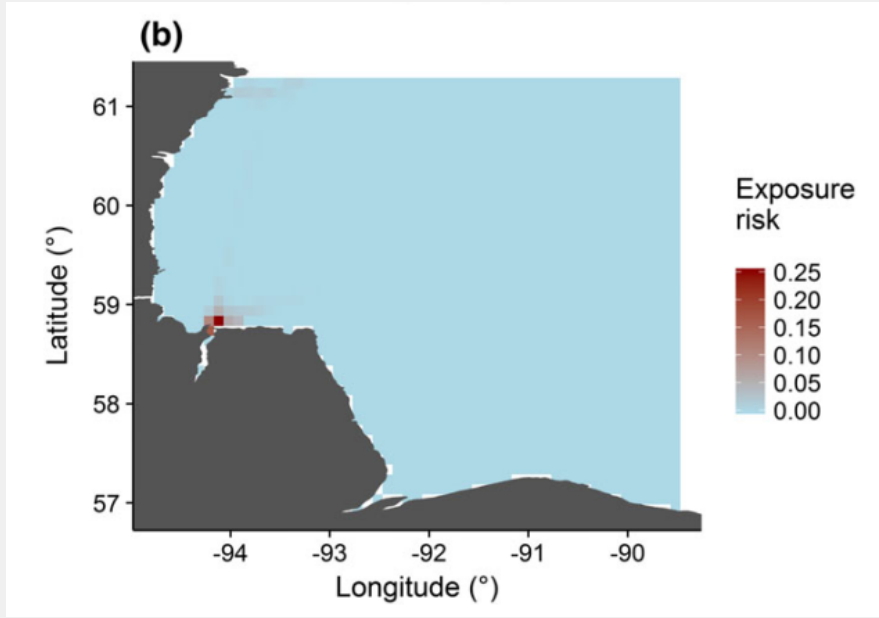
2. Risk maps

https://baleinesendirect.org/en/discover/whales-future/threats/

<u>Example:</u> Exposure of belugas (*Delphinapterus leucas*) to shipping traffic







Pirotta et al. 2018

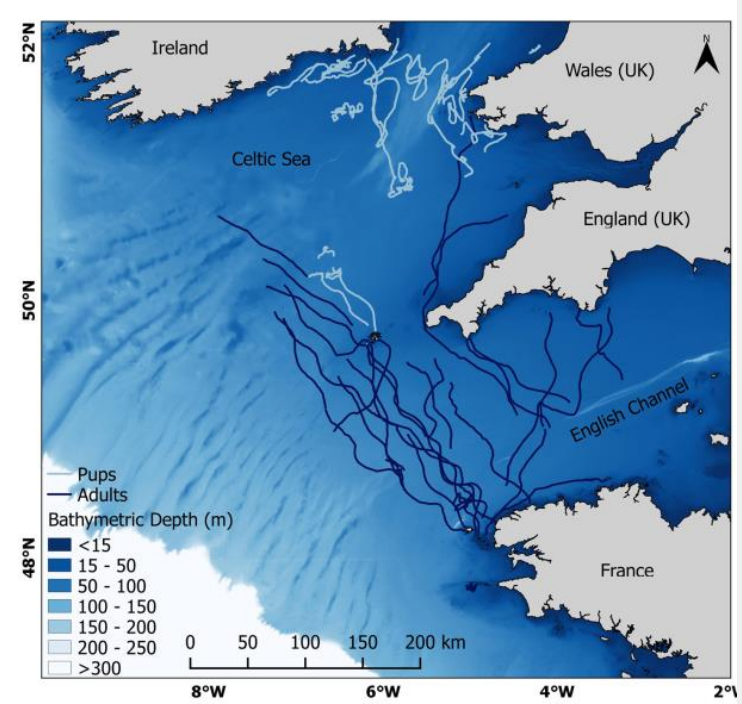
3. Association of vessel movements with individual animal movements

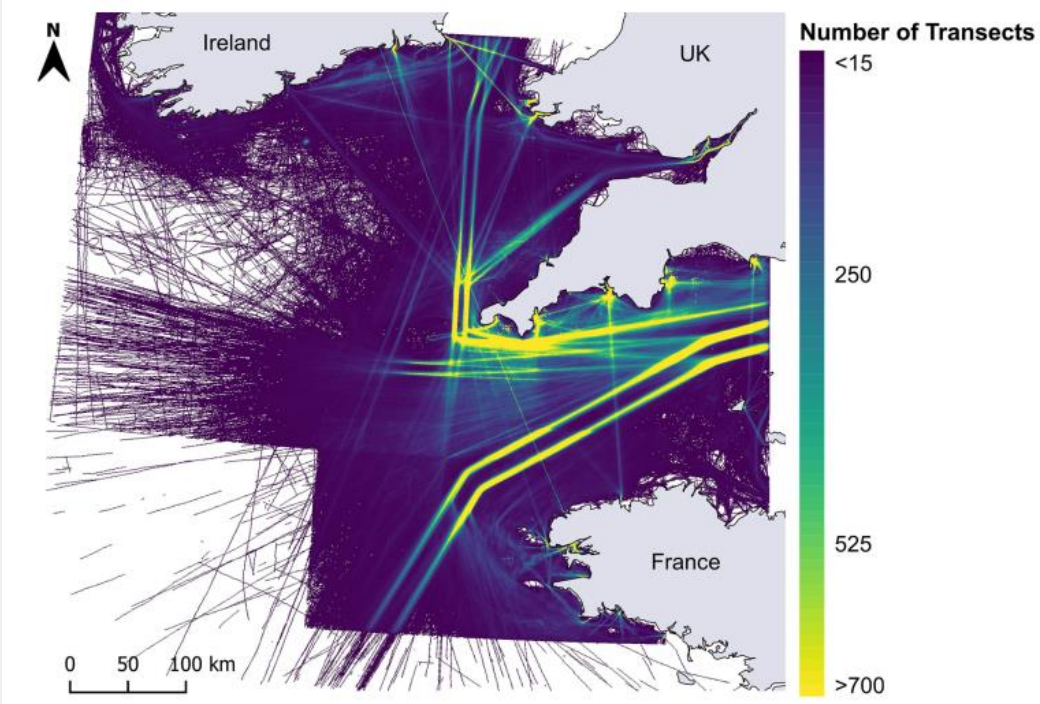
- Combine contemporary AIS vessel tracks with animal movement trajectories from satellite telemetry


Photo: Abbo van Neer

3. Association of vessel movements with individual animal movements

Example: Exposure of diving grey seals (*Halichoerus grypus*) to vessel noise





Trigg et al. 2020

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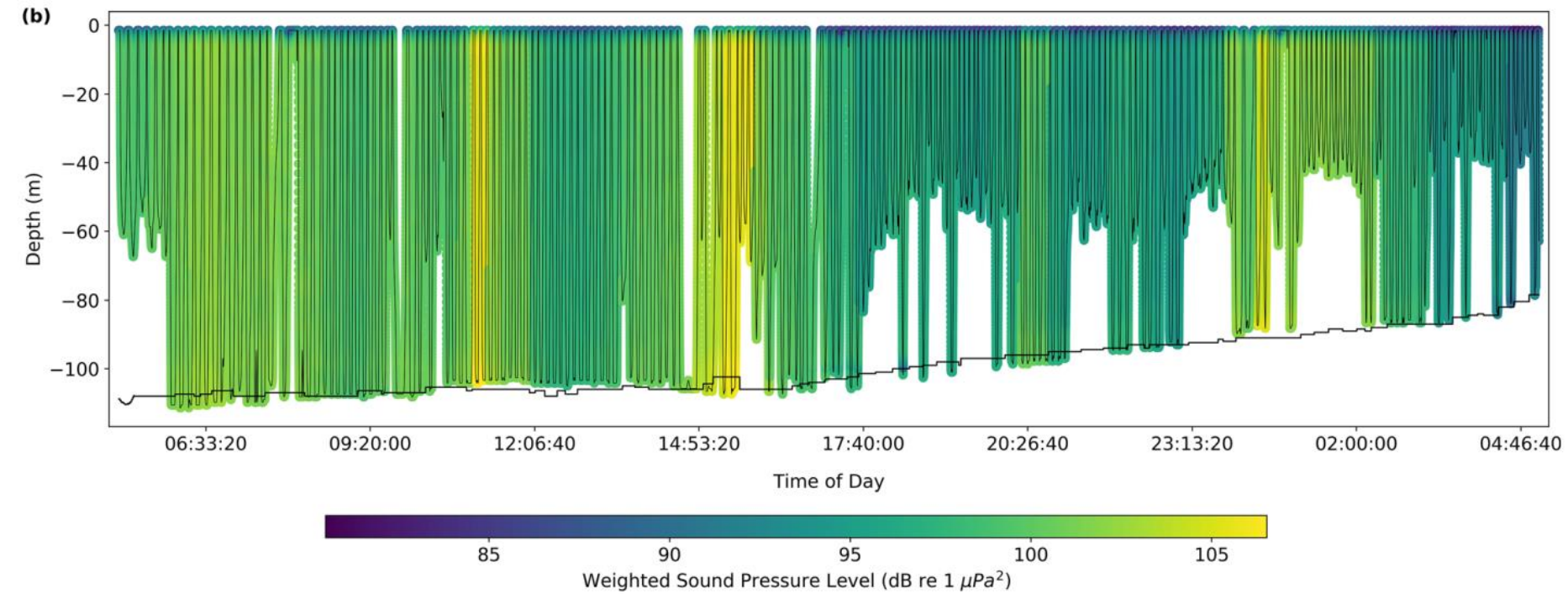
Example: Exposure of diving grey seals (*Halichoerus grypus*) to vessel noise



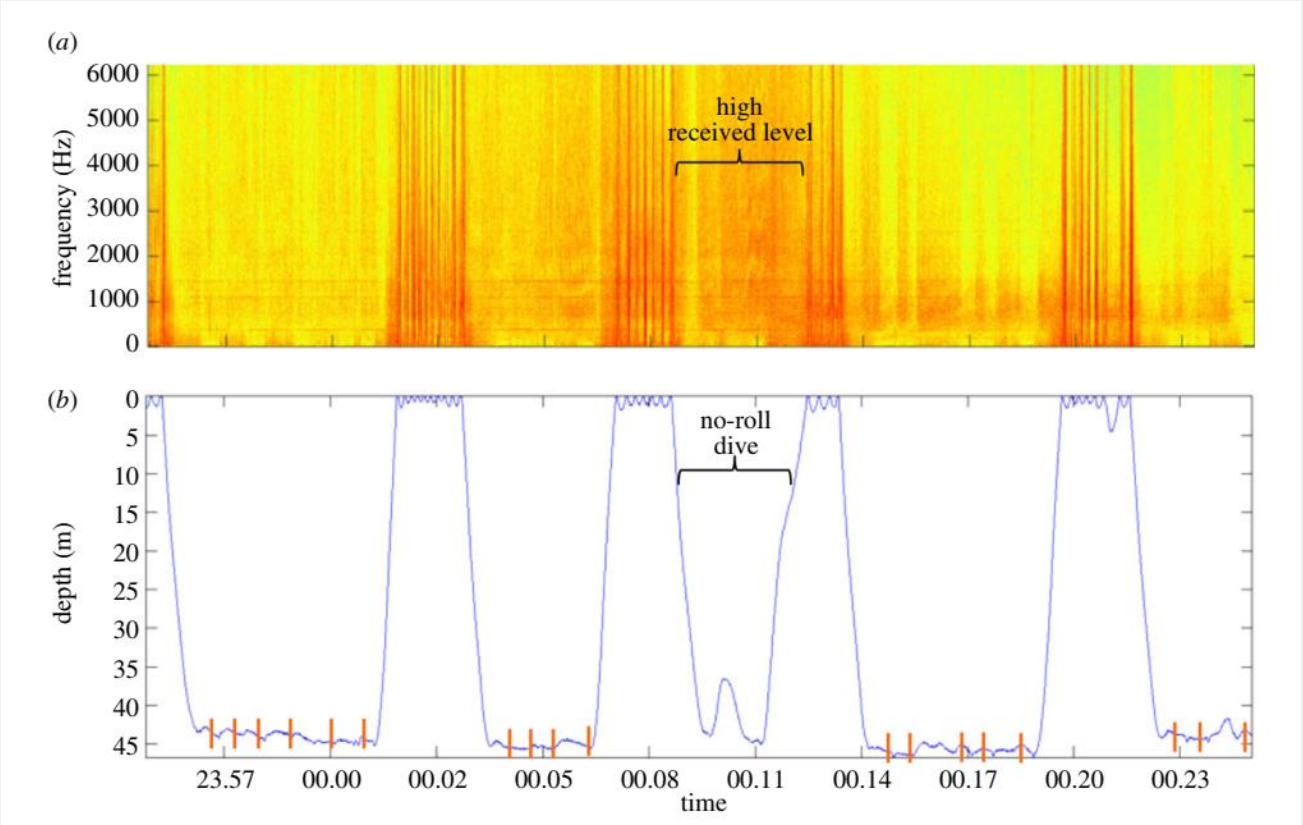
Trigg et al. 2020

4. Deployment of sound and movement biologging tags (DTAGs)

- Recording of movements, behaviour and sound exposure directly on the animal

4. Deployment of sound and movement biologging tags (DTAGs)

Example: Humpback whales reduce foraging effort in response to high levels of ship noise



Blair et al. 2016

Pilot whales (n=22)

Harbour porpoises (n=33)

Harbour seals (n=18)

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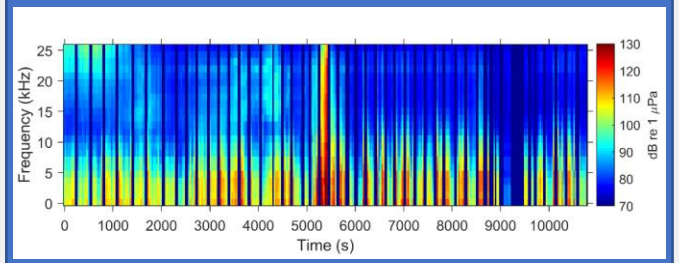
Challenges of quantifying ship noise exposures

How to detect and classify ship noise events in long-term acoustic recordings?

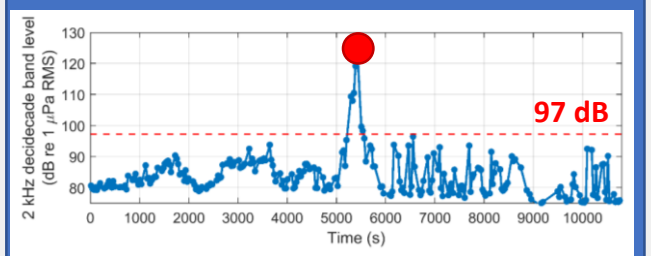
Sound and movement tag (DTAGs) recordings
(9 seals, 162 days of data)

VESSEL DETECTION

Decidecade band levels
(30 s averages, excl. surfacings)



High-amplitude noise events
(fixed threshold of 97 dB re 1 µPa @ 2 kHz)



VESSEL CLASSIFICATION

Noise event classification


Vessel noise


Rain, etc.

Nachtsheim et al. 2023

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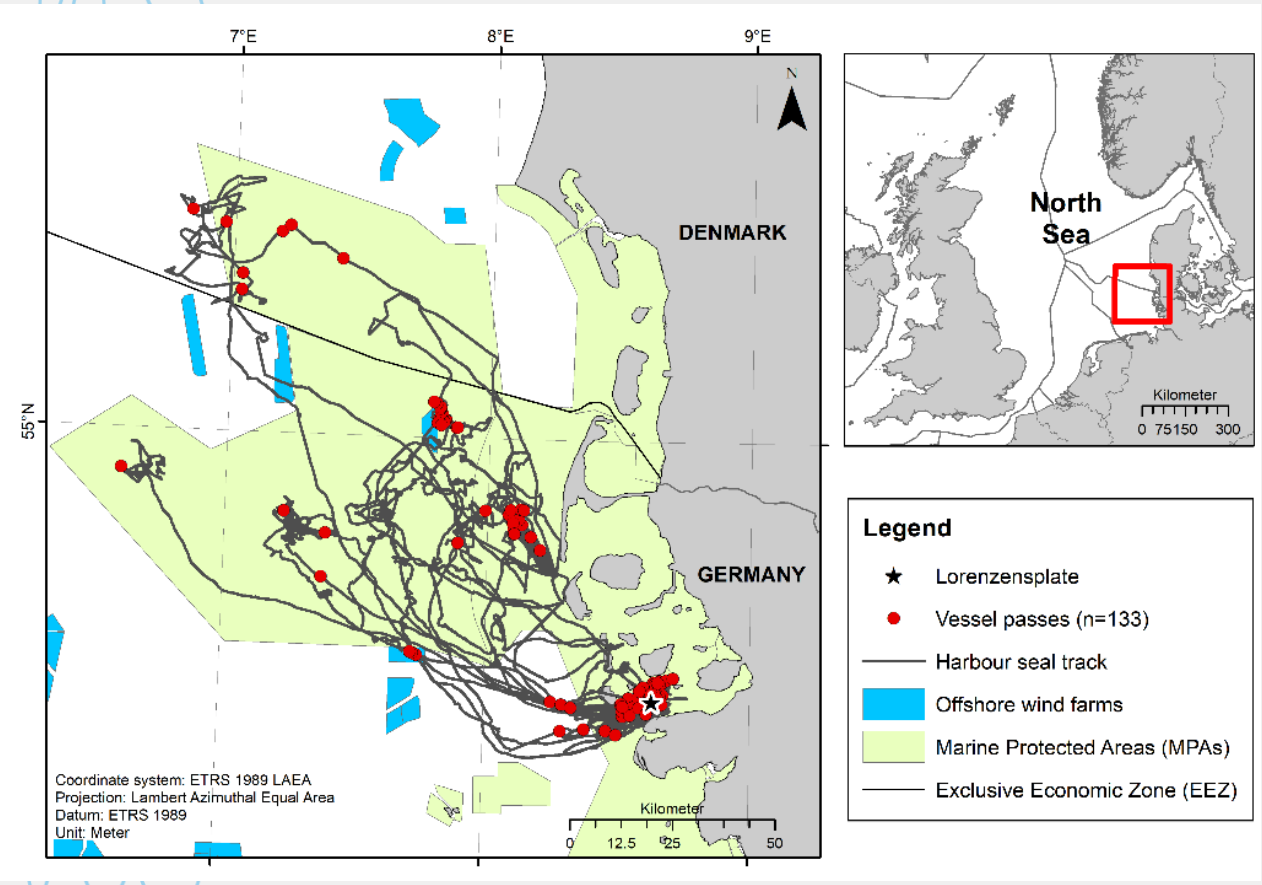
Challenges of quantifying ship noise exposures



CONCLUSION

- Harbour seals from the Wadden Sea exposed to **4.3 ± 1.6 vessel passes per day**
- Only **32% of vessel passes were plausibly associated with AIS vessels** demonstrating that AIS data is a poor stand-alone predictor of vessel noise impacts on North Sea seals

Nachtsheim et al. 2023

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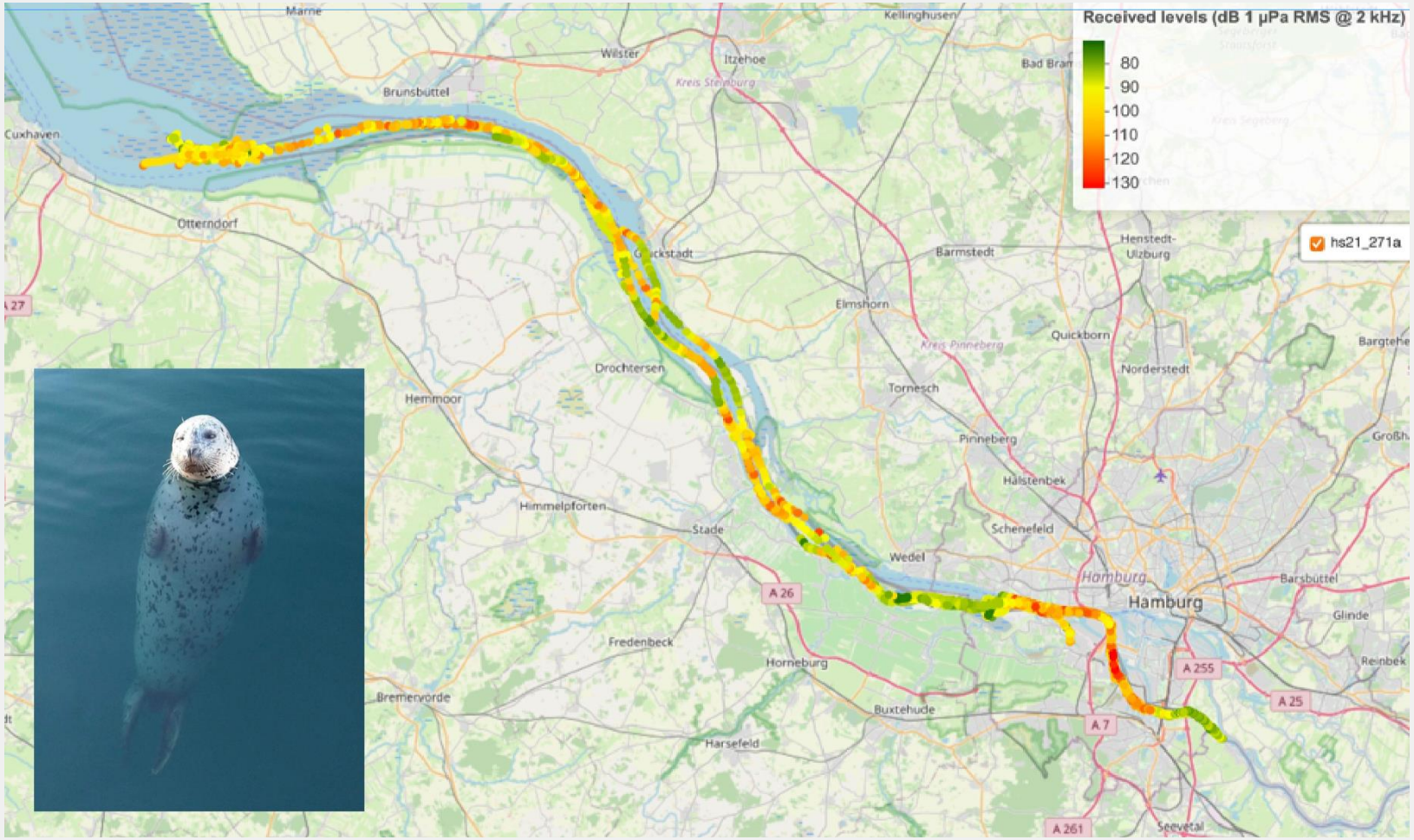
Challenges of quantifying ship noise exposures



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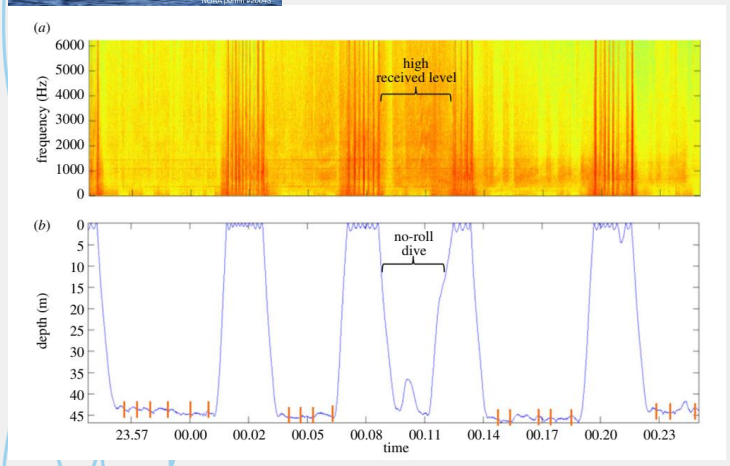
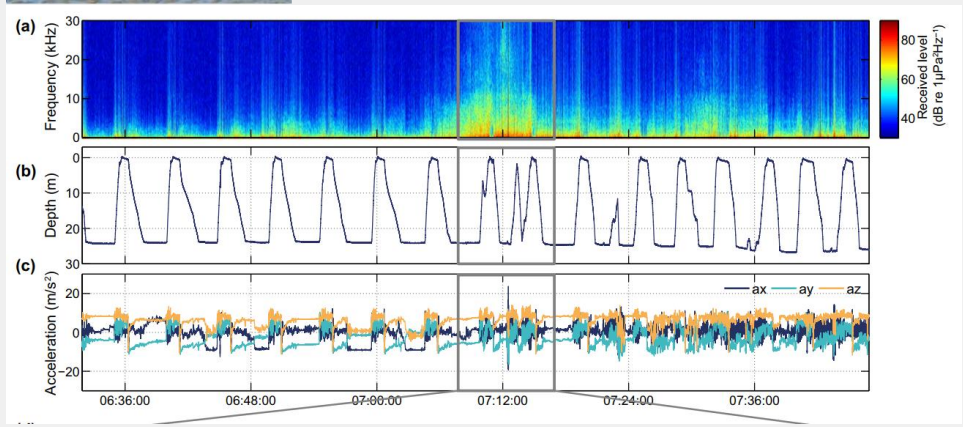
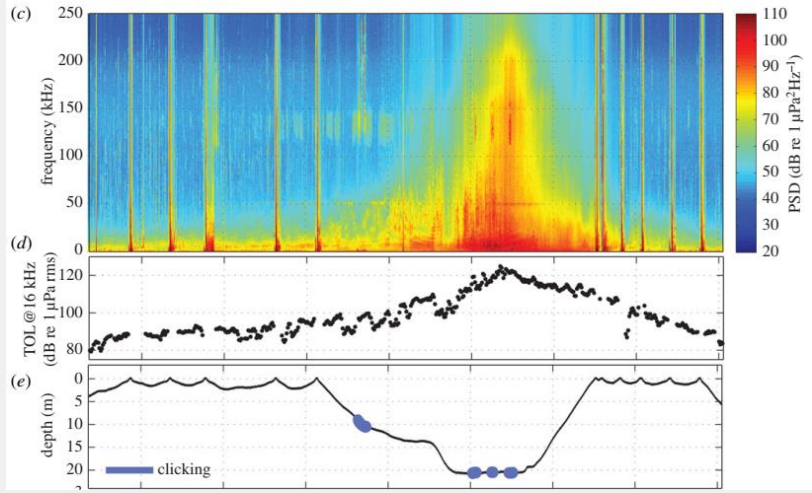
Challenges of quantifying <u>impacts</u> of ship noise



Blair et al. 2016



Mikkelsen et al. 2019



Wisniewska et al. 2018

WHAT ARE THE ENERGETIC COSTS?

Challenges of quantifying impacts of ship noise

Ingestion

Essential processes
Maintenance, Thermoregulation, Locomotion

Non-essential processes
Reproduction, Growth, Storage

ENERGY INTAKE

Prey capture attempts (PCAs)
- Buzz (toothed whales)
- Acceleration transients (seals)

ENERGY EXPENDITURE

Essential processes
- Metabolic rates (toothed whales)
- Locomotion (seals)

modified from Gallagher et al. 2021

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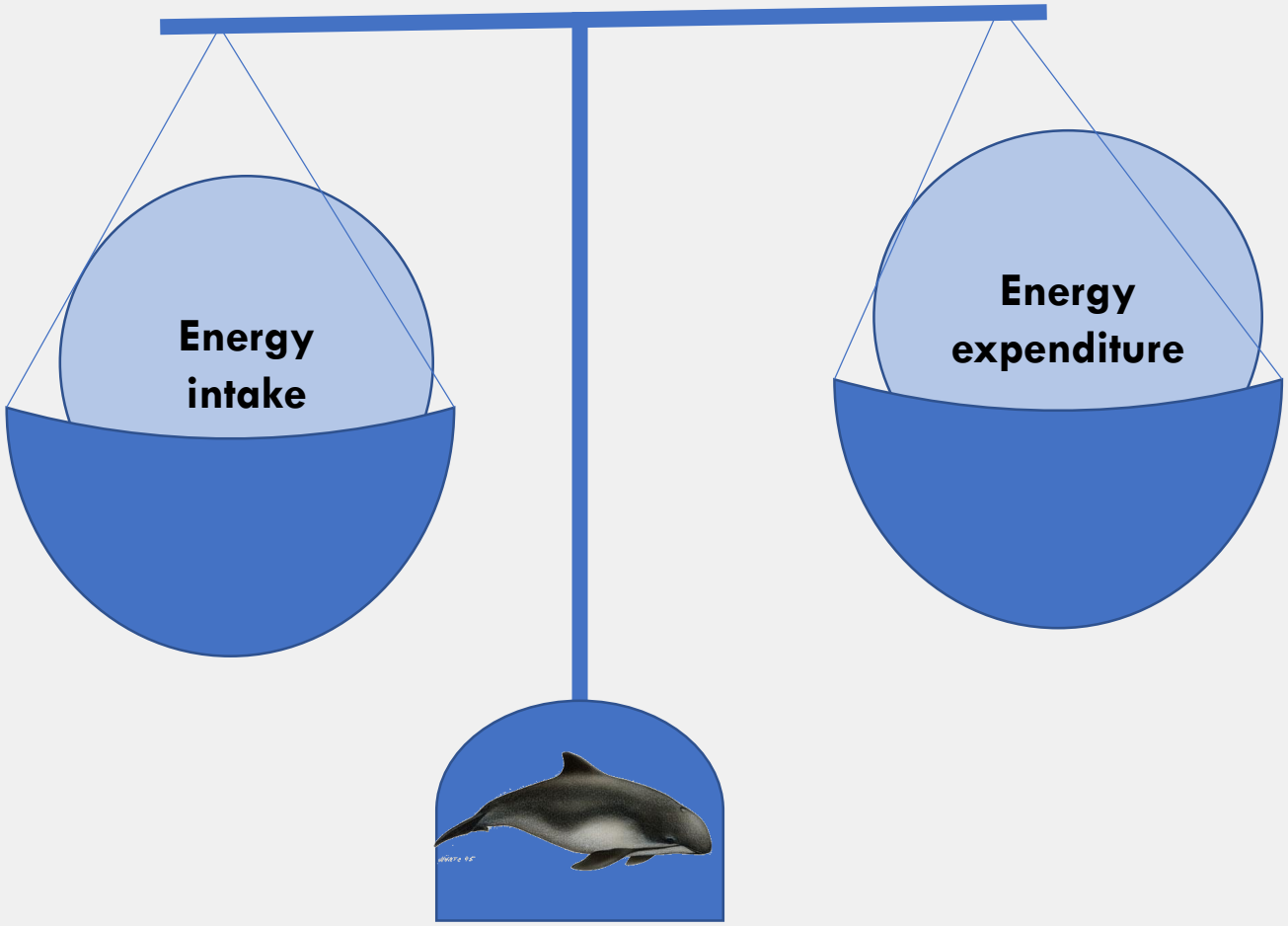
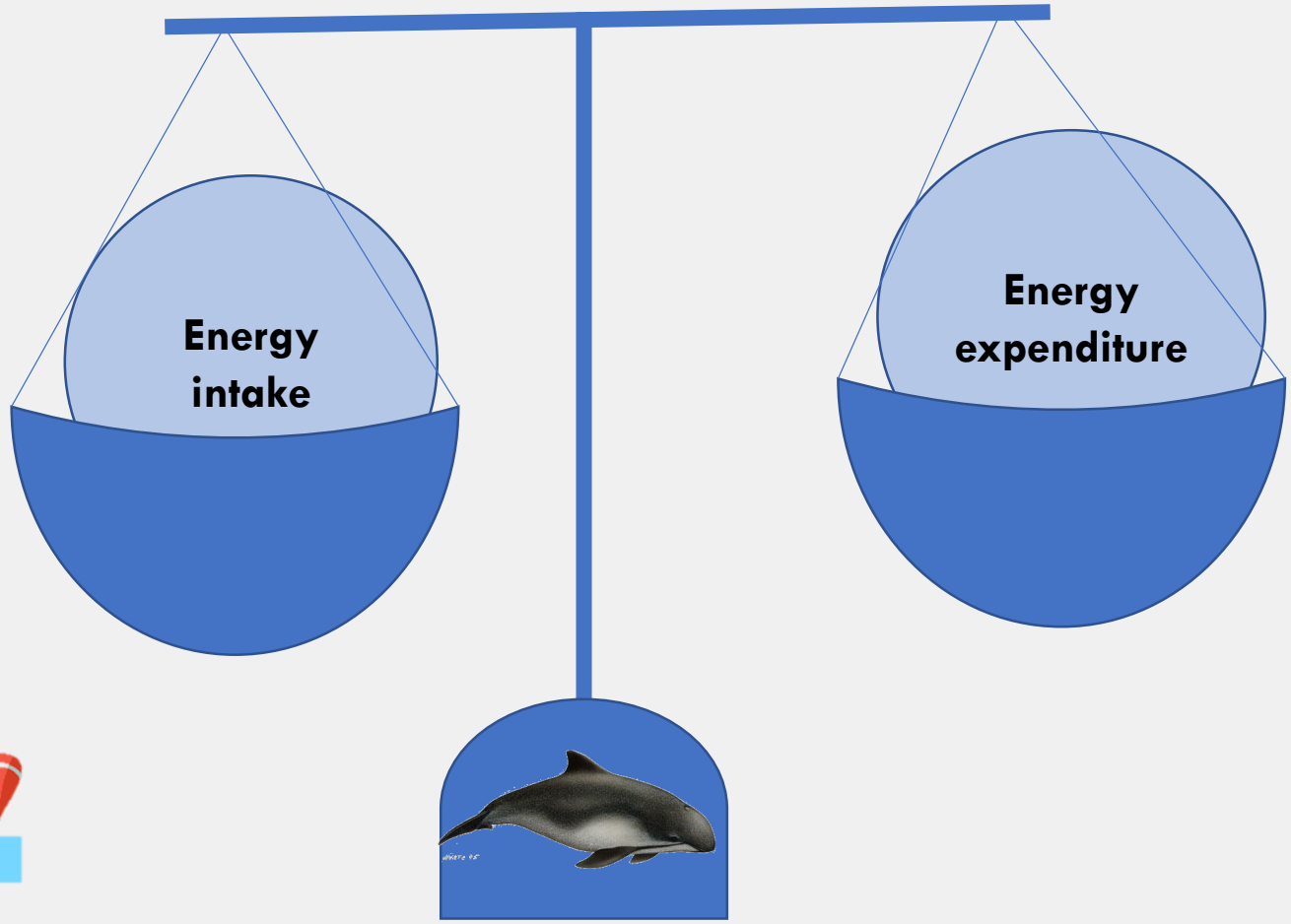
Challenges of quantifying impacts of ship noise



Challenges of quantifying impacts of ship noise



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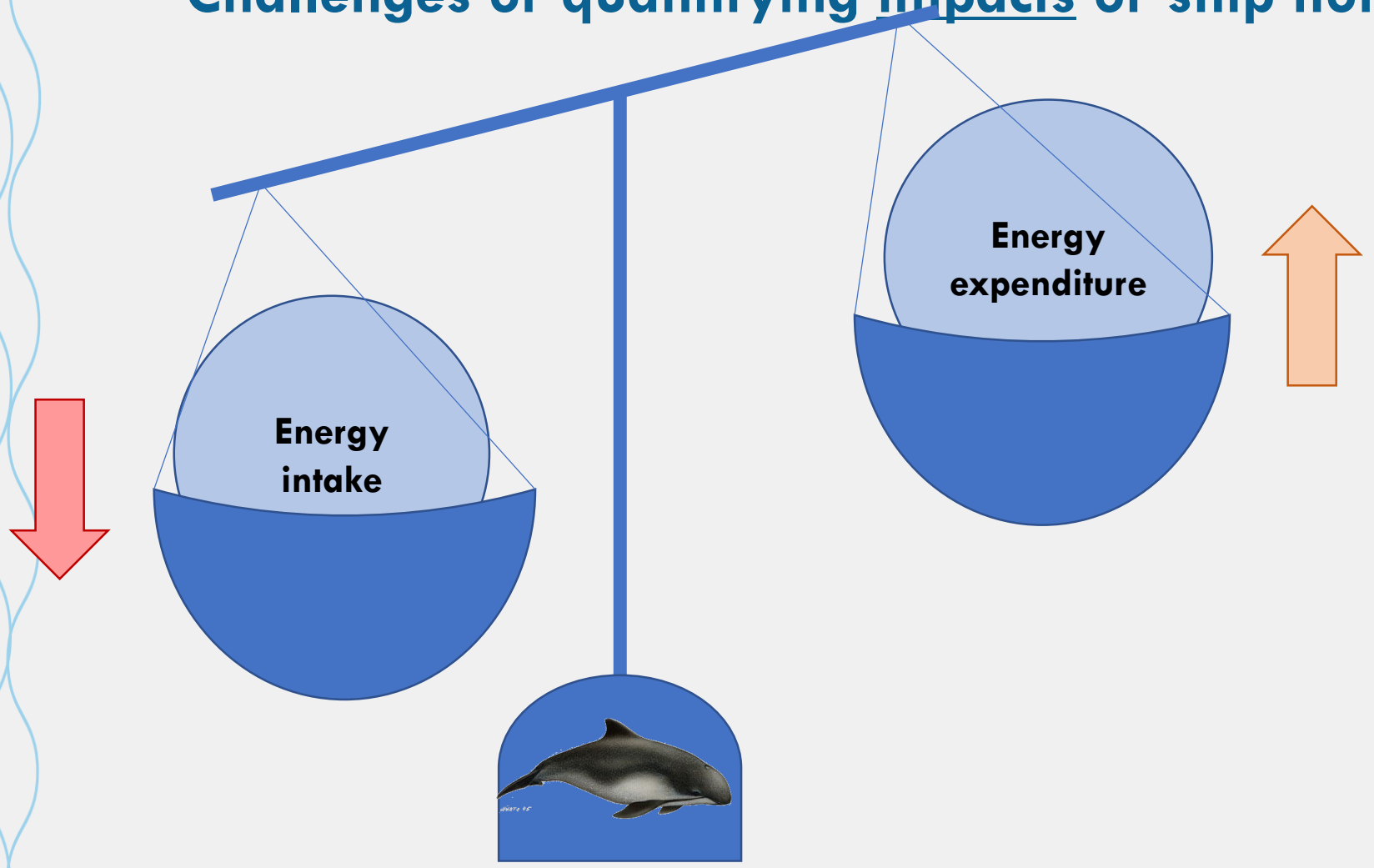

Challenges of quantifying impacts of ship noise

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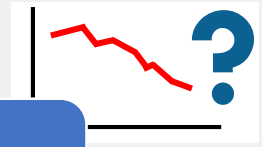
ENERGY INTAKE

ENERGY EXPENDITURE



Net energy loss → **Individual fitness?** → **Population consequences?**

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Thank you for your attention!

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