How marine mammals respond to underwater ambient noise

Fannie W. Shabangu
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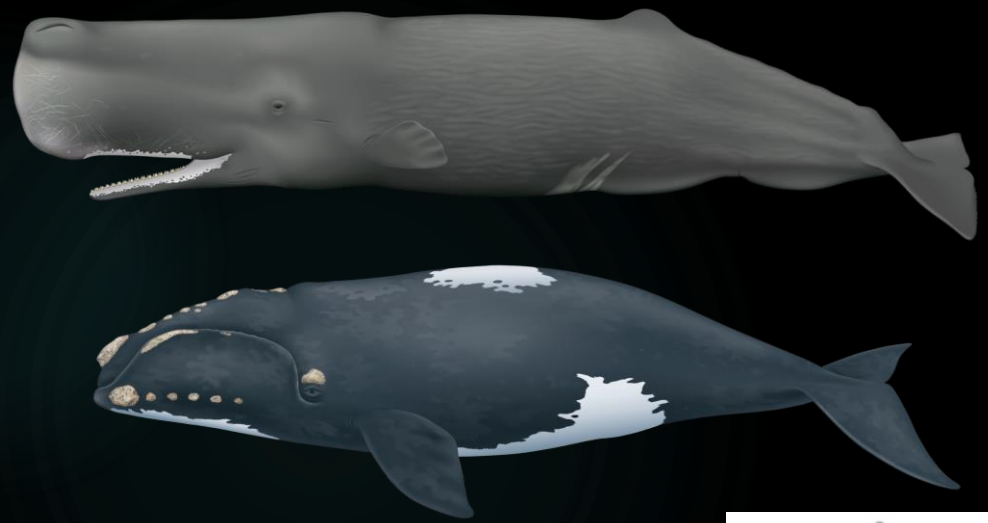

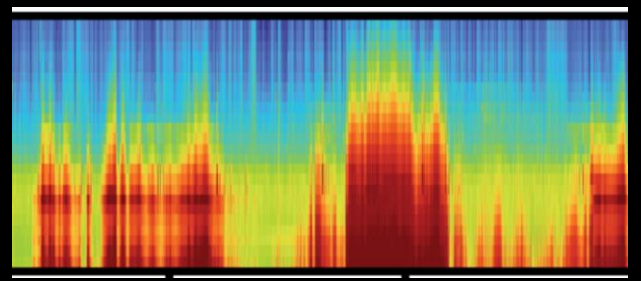

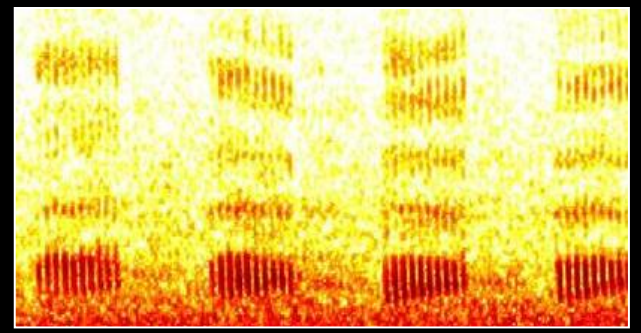

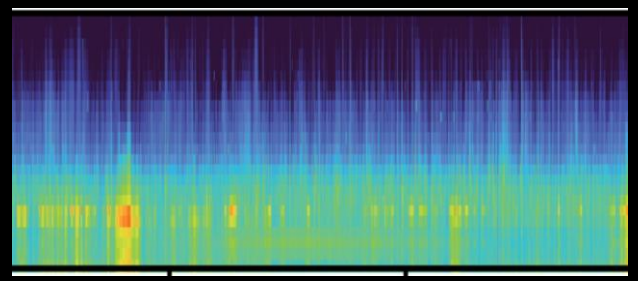

forestry, fisheries & the environment
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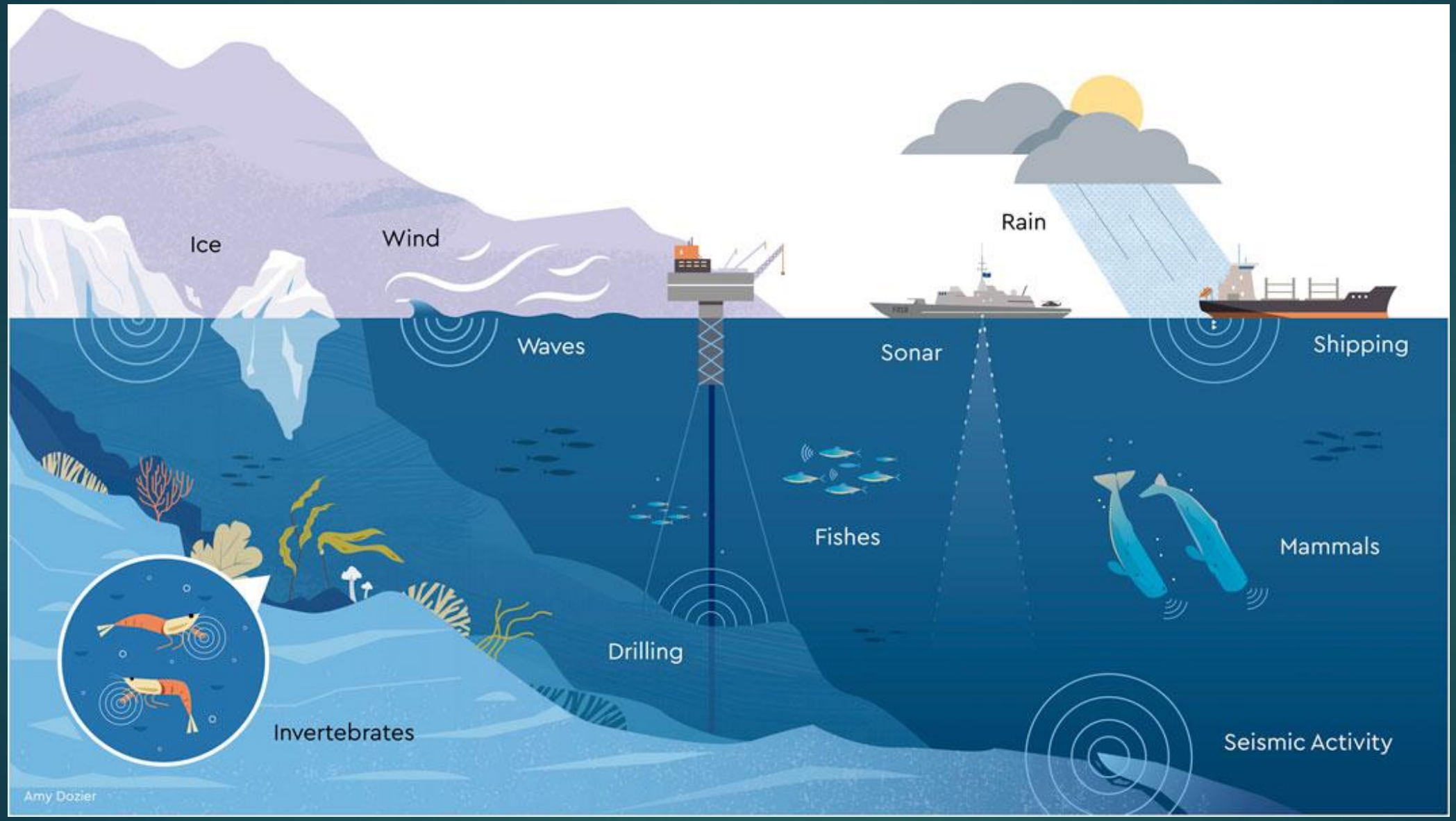
WHALE UNIT

25 October 2023
DOSITS Webinar

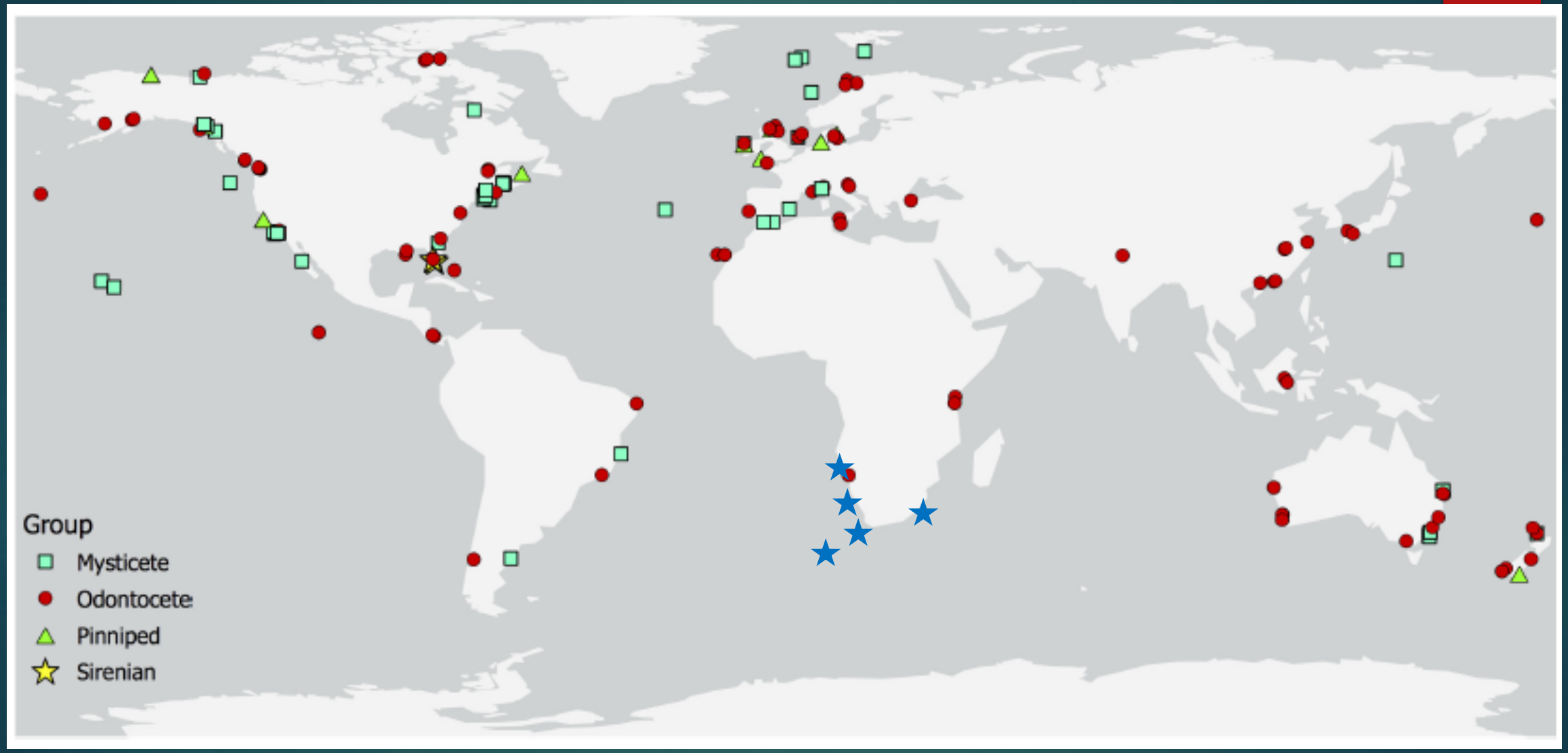
Underwater sounds



- Biophony
- Geophony
- Anthropophony

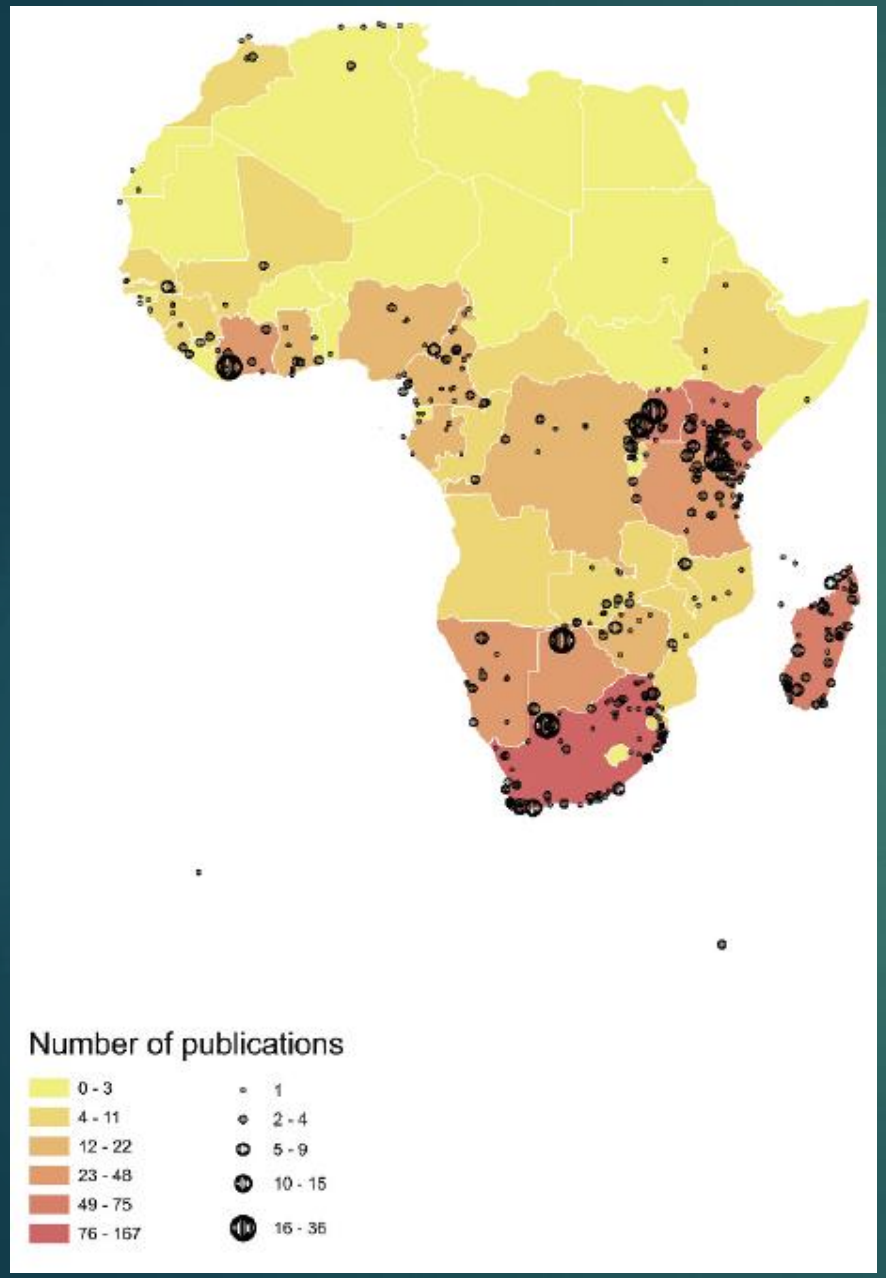
Cauchy et al. (2023) Gliders for passive acoustic monitoring of the oceanic environment. Front Mar Sci

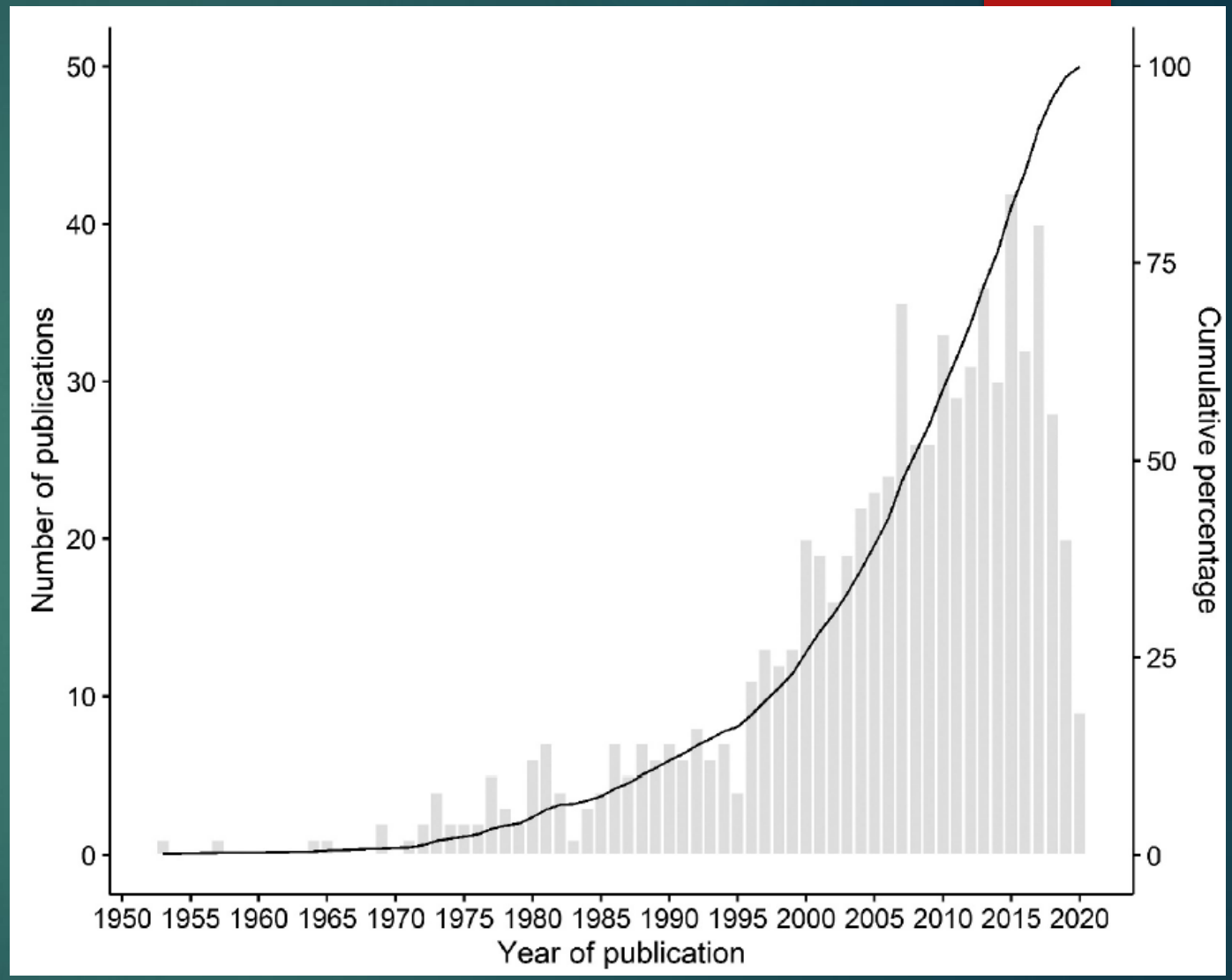
Global noise studies



Erbe et al. (2019) The effects of ship noise on marine mammals—A review. Front Mar Sci

Africa specific bioacoustics research



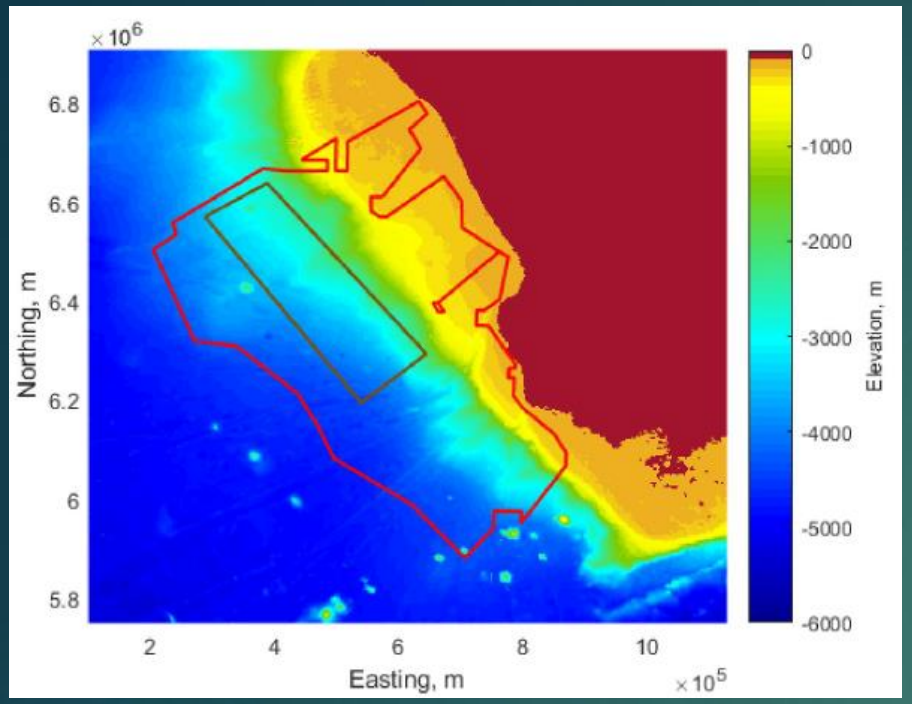


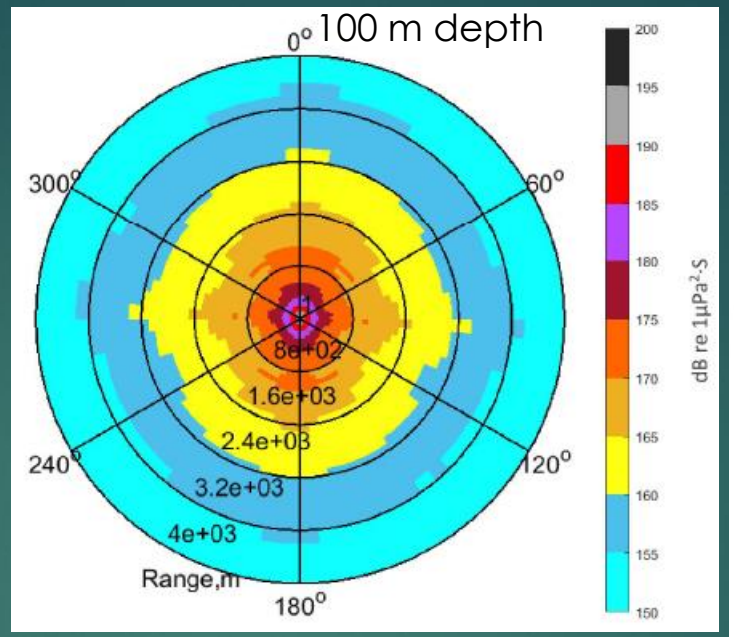
Becker et al. (2021) Sounding out a continent: seven decades of bioacoustics research in Africa. Bioacoustics

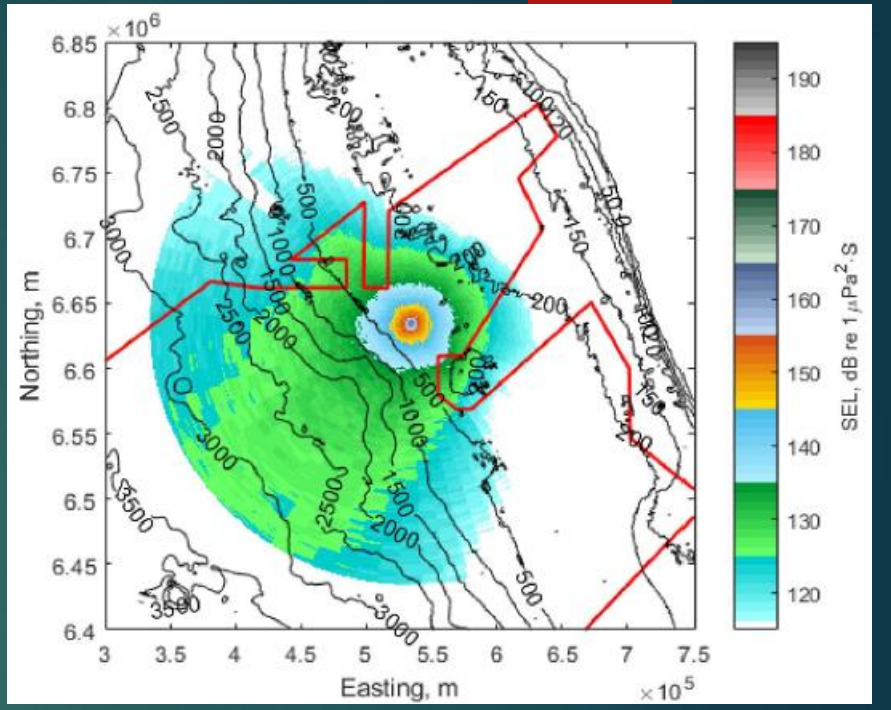
Operation Phakisa: Sectors to develop

1) Marine transport and manufacturing
2) Offshore oil and gas exploration
3) Aquaculture
4) Marine protection services and ocean governance
5) Tourism
6) Small harbour and infrastructural development

NO BASELINE NOISE DATA

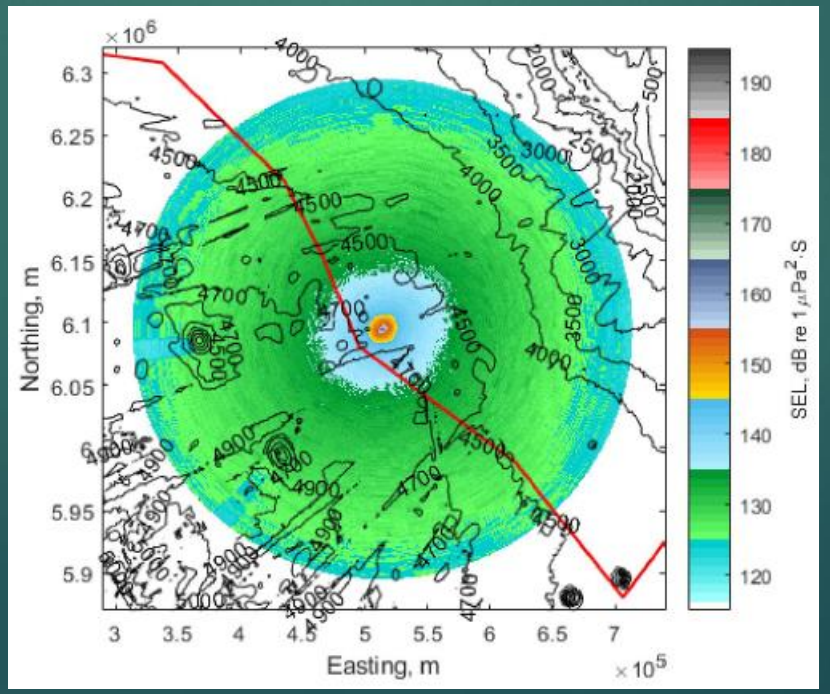


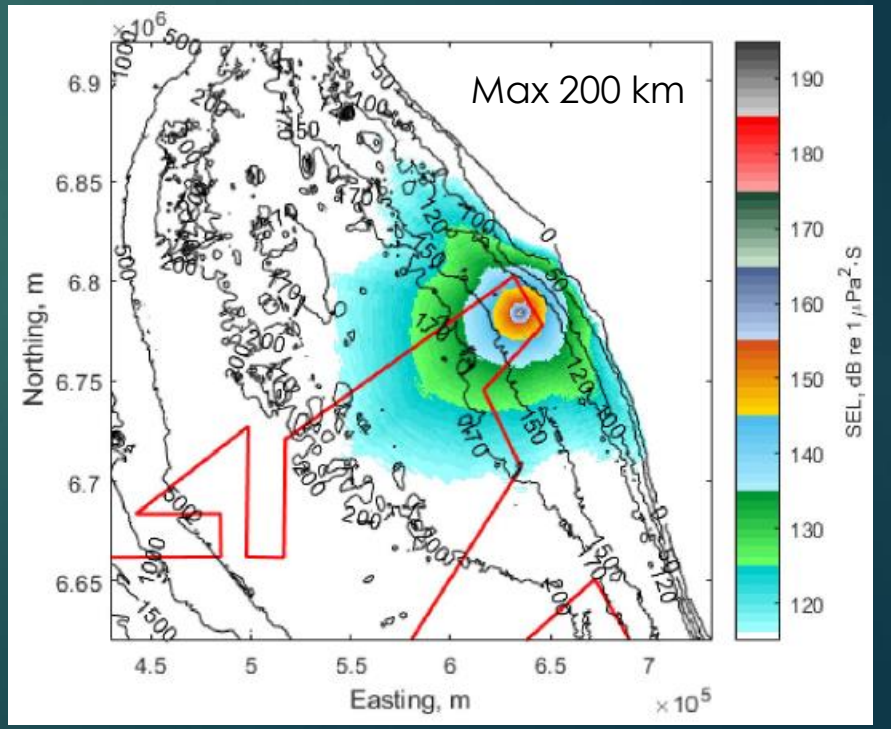




Acoustic modelling (sound exposure levels):

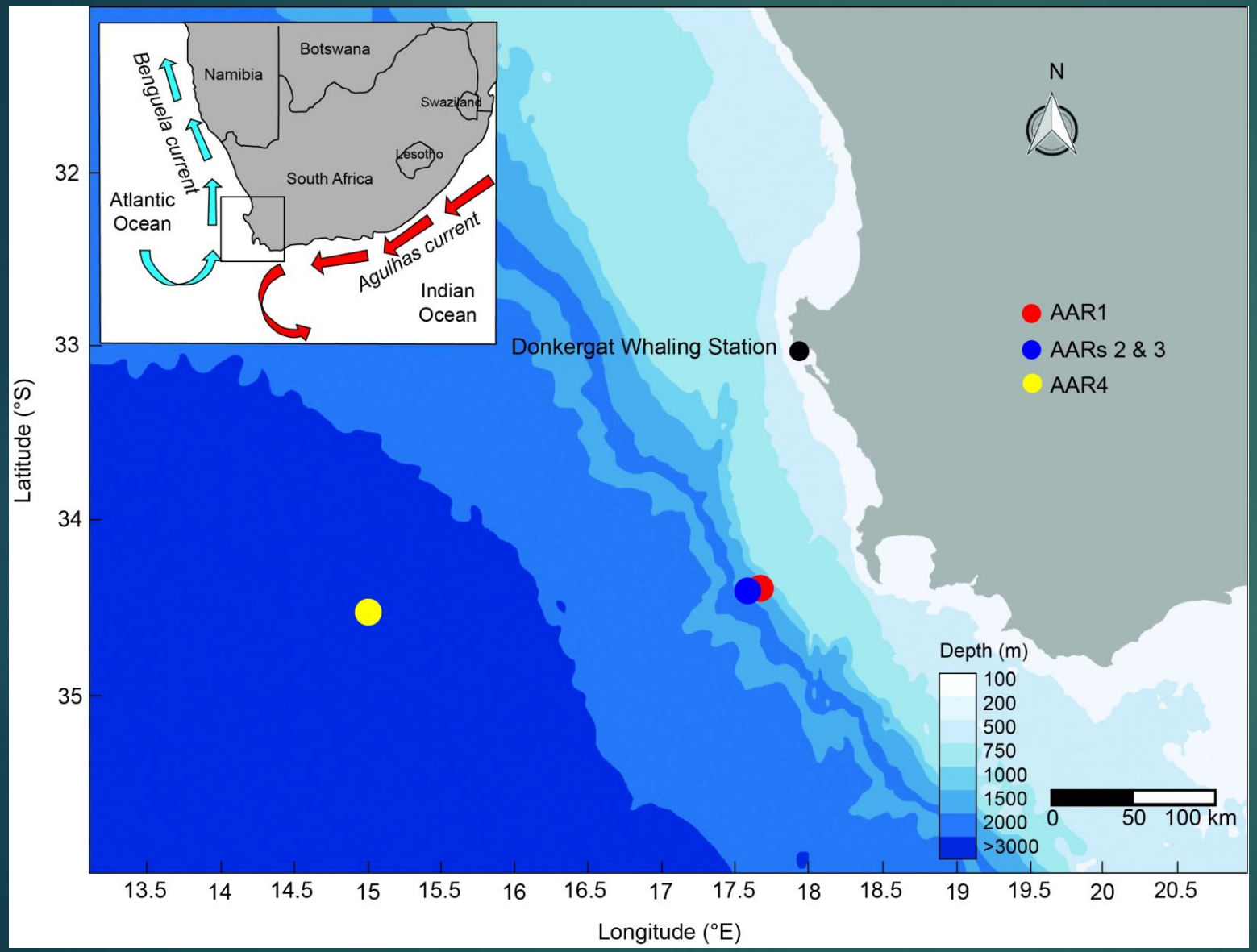
- Noise risk assessment
- Environmental impact assessment



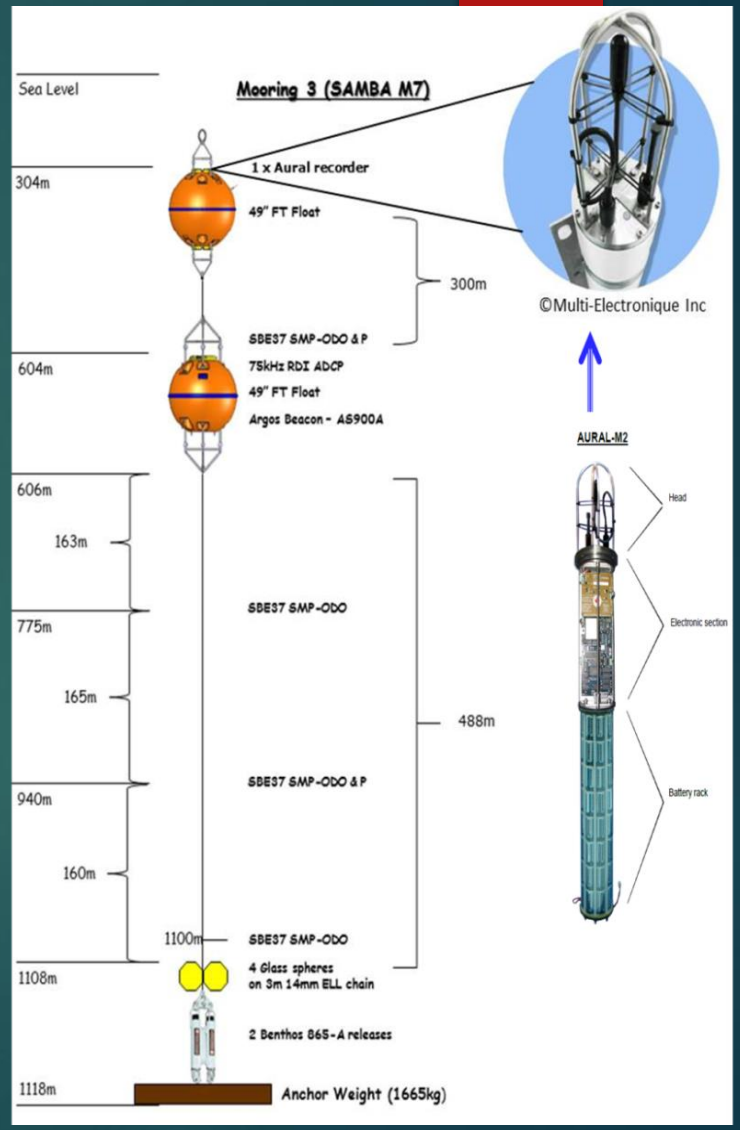


SLR Consulting Australia (2021) Report

PAM off the west coast of South Africa

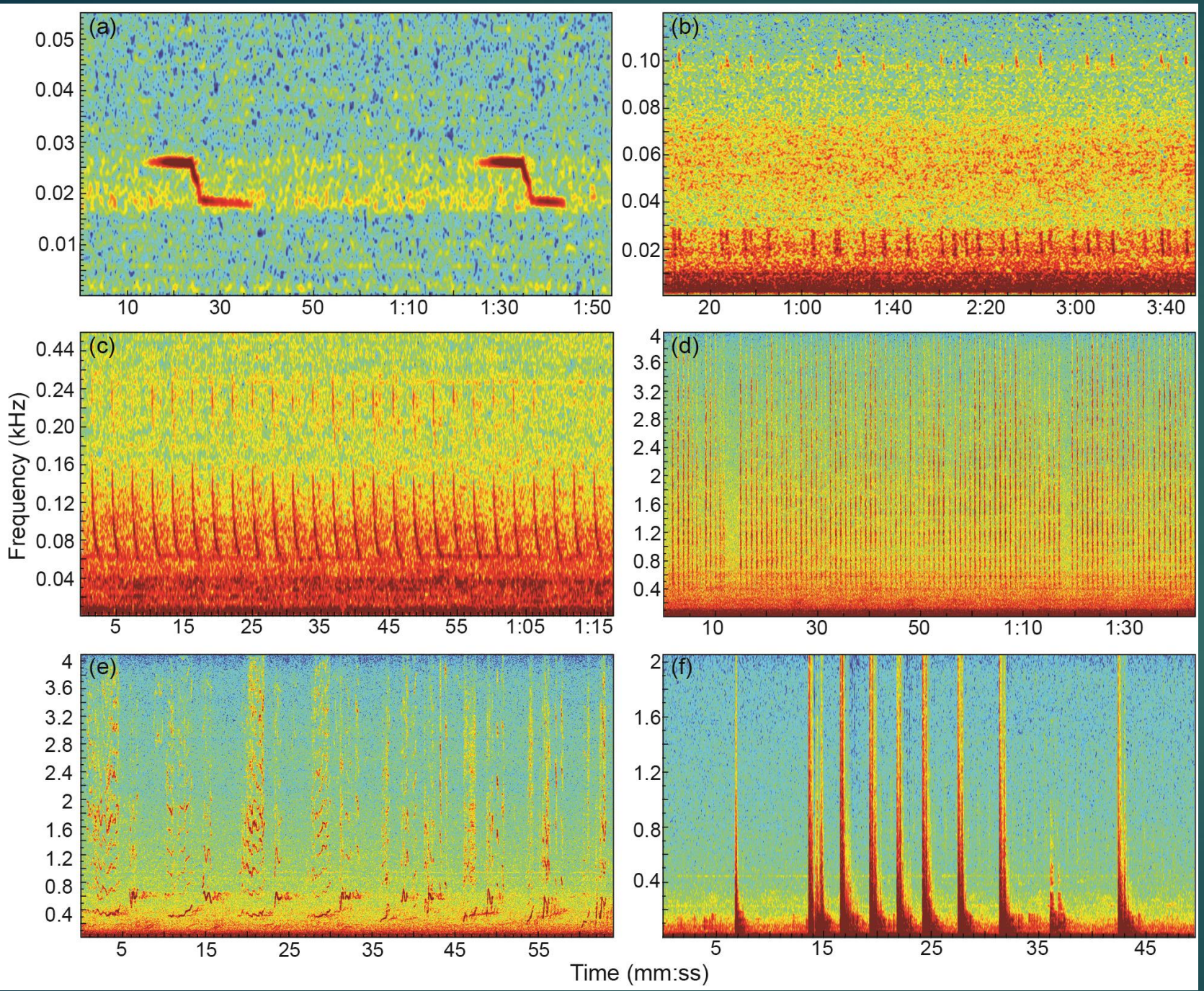


SAMBA oceanographic mooring

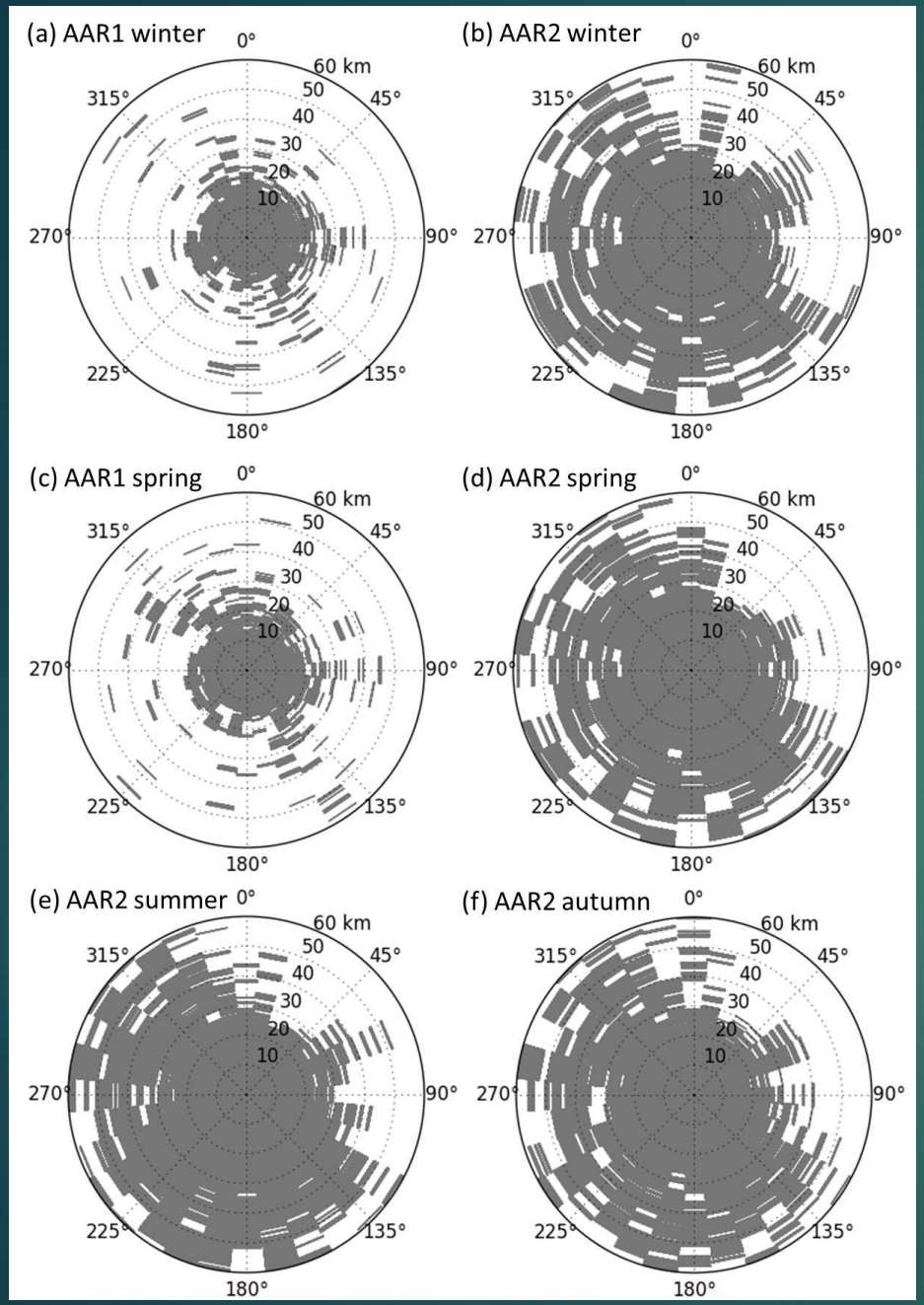


- Duty cycling - Onboard data archival - Long-term deployment: 2014-2017, 2023- onward

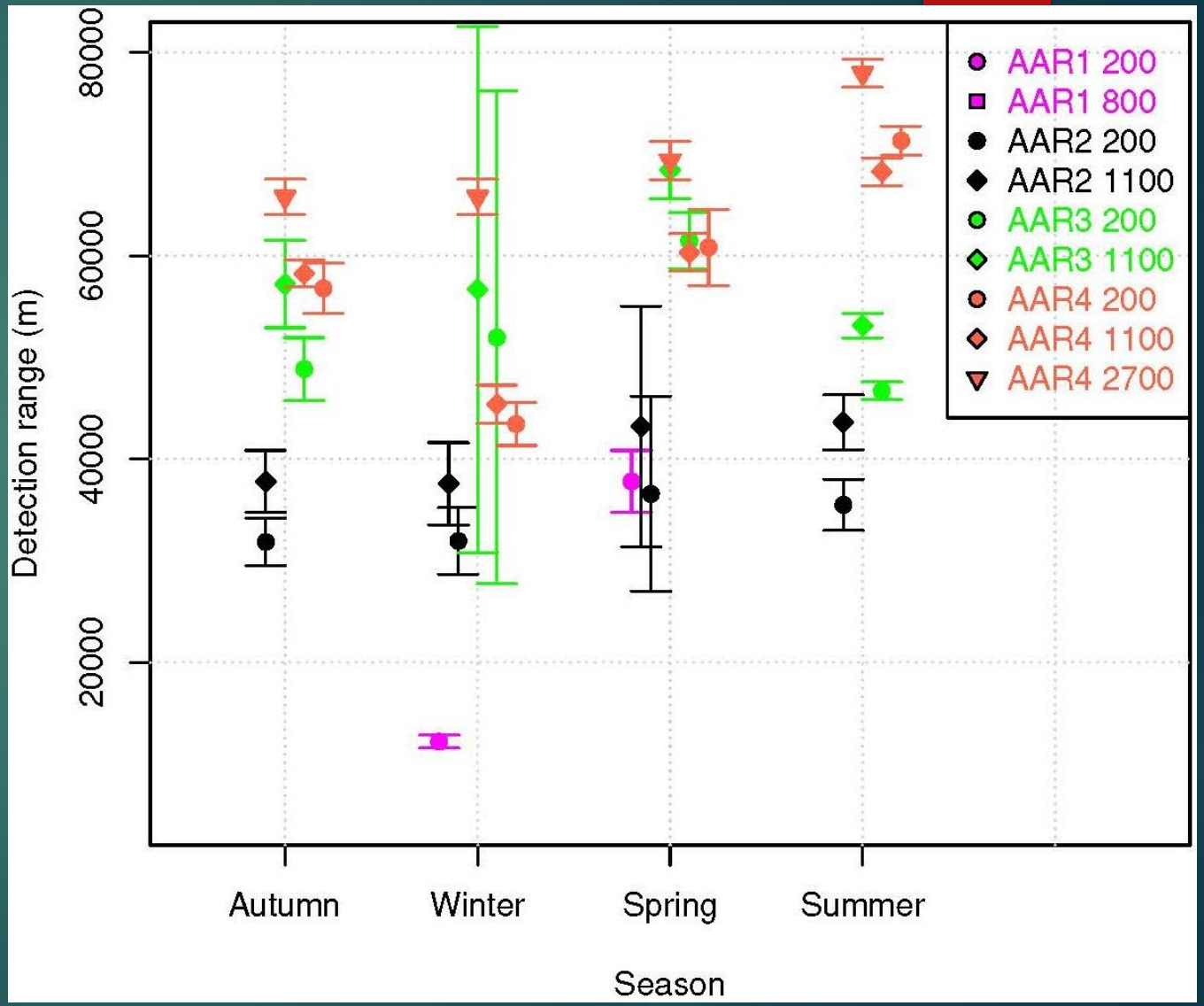
Detected whale calls



Whale call detection ranges off the west coast of SA

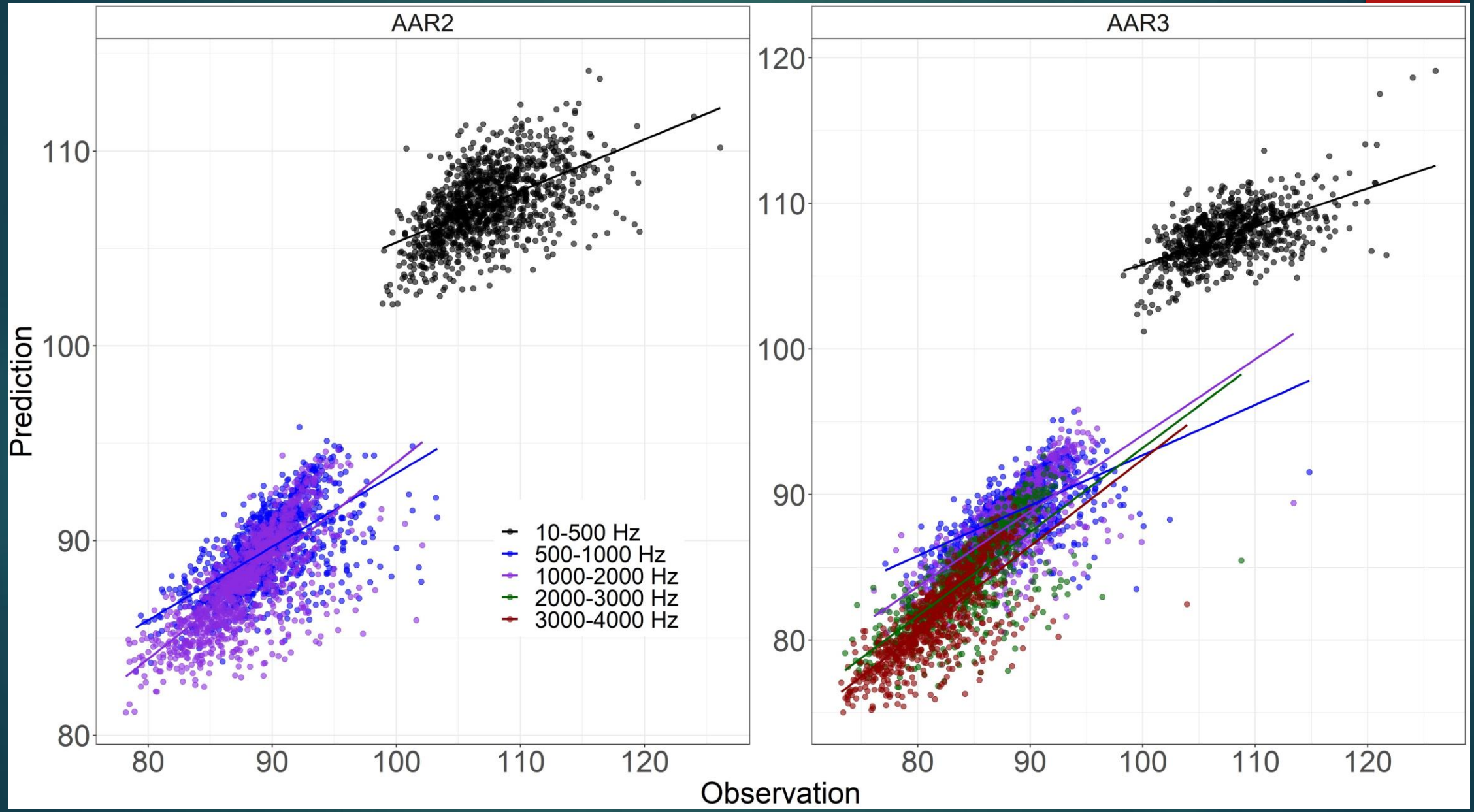


Shabangu et al. (2019) Antarctic blue whales. J Mar Sys



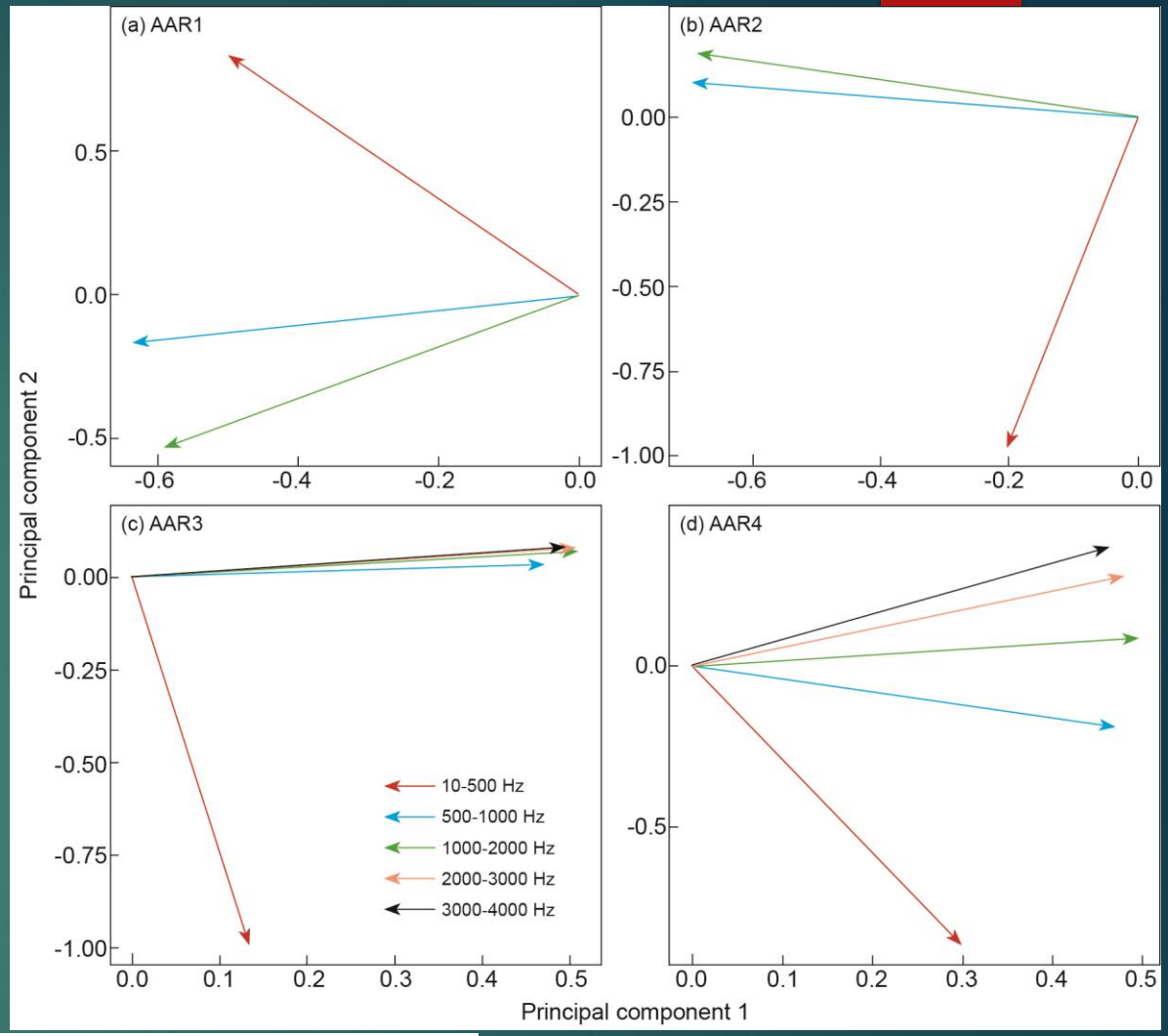
Shabangu & Andrew (2020) Sperm whale clicks. Endang Spec Res

Noise at different frequency bands



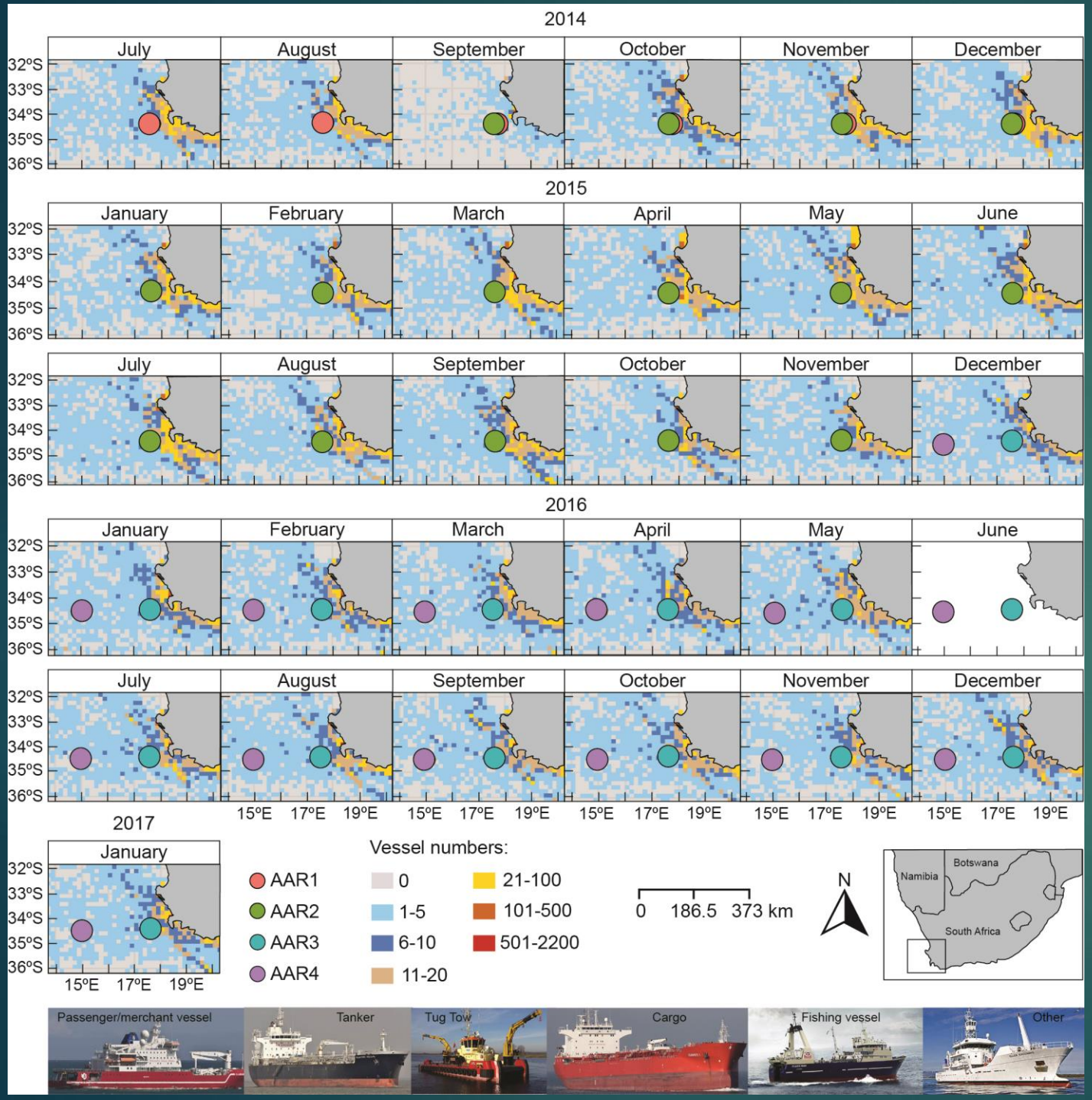
Noise statistics

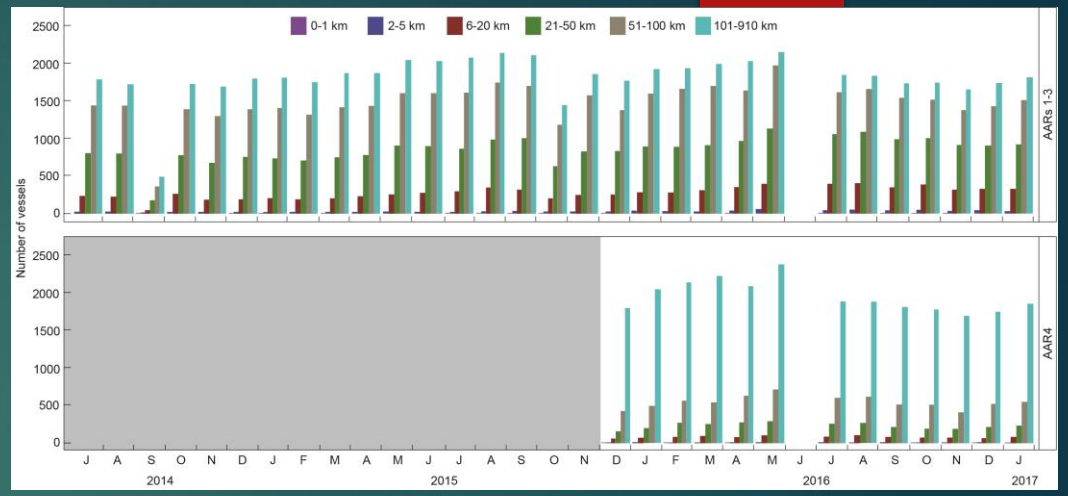
- Autocorrelation between frequency bands
- No multi-collinearity between environmental variables
- Ocean current speed > 11 cm s^{-1} filtered out
- Data from AAR1 and AAR4 excluded from noise analysis due to high pseudo-noise

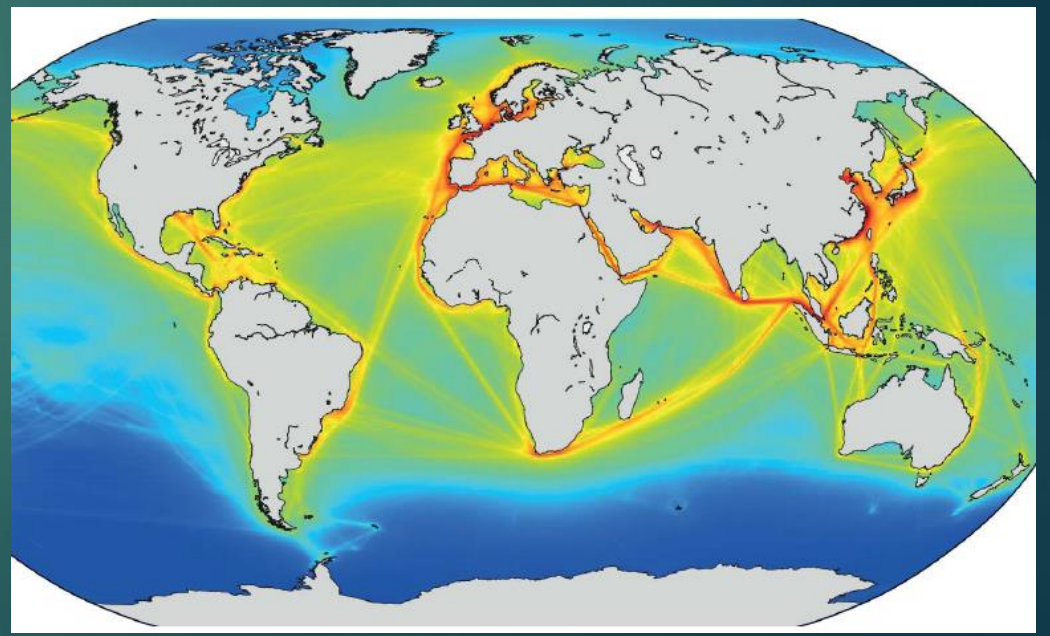


Model	Formula
Noise level RF model	$L_{eq} \sim Month + Hour + wind\ speed + wind\ direction + total\ precipation + Wave\ height + Wave\ period + Number\ of\ vessels + Current\ speed$
Whale detection GLM model	$Species\ detection \sim Lowest\ frequency\ band + Highest\ frequency\ band$

Vessel traffic

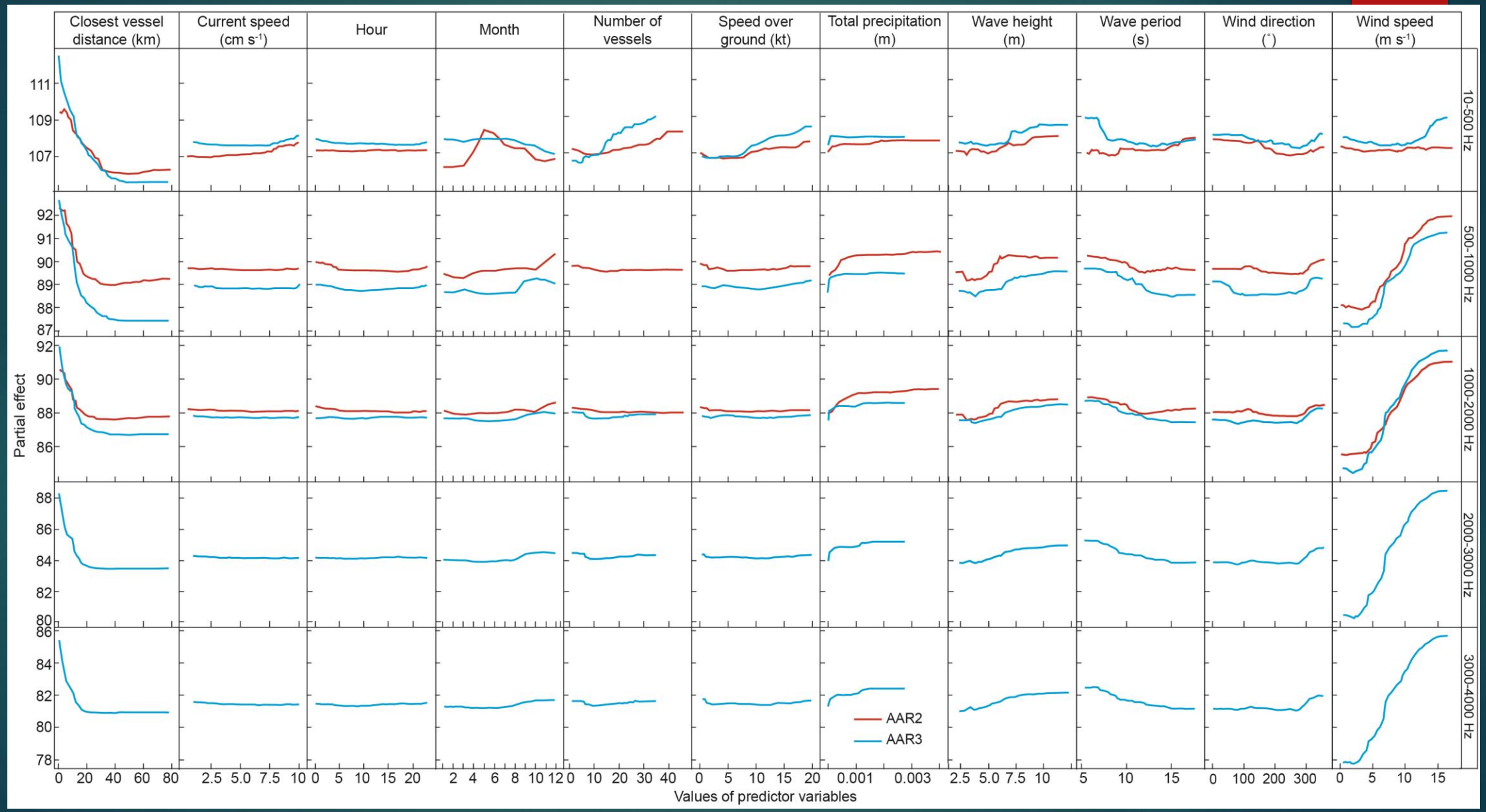






Shabangu et al. (2022) Whales and underwater noise. Mar Pol Bul

Sources of underwater noise



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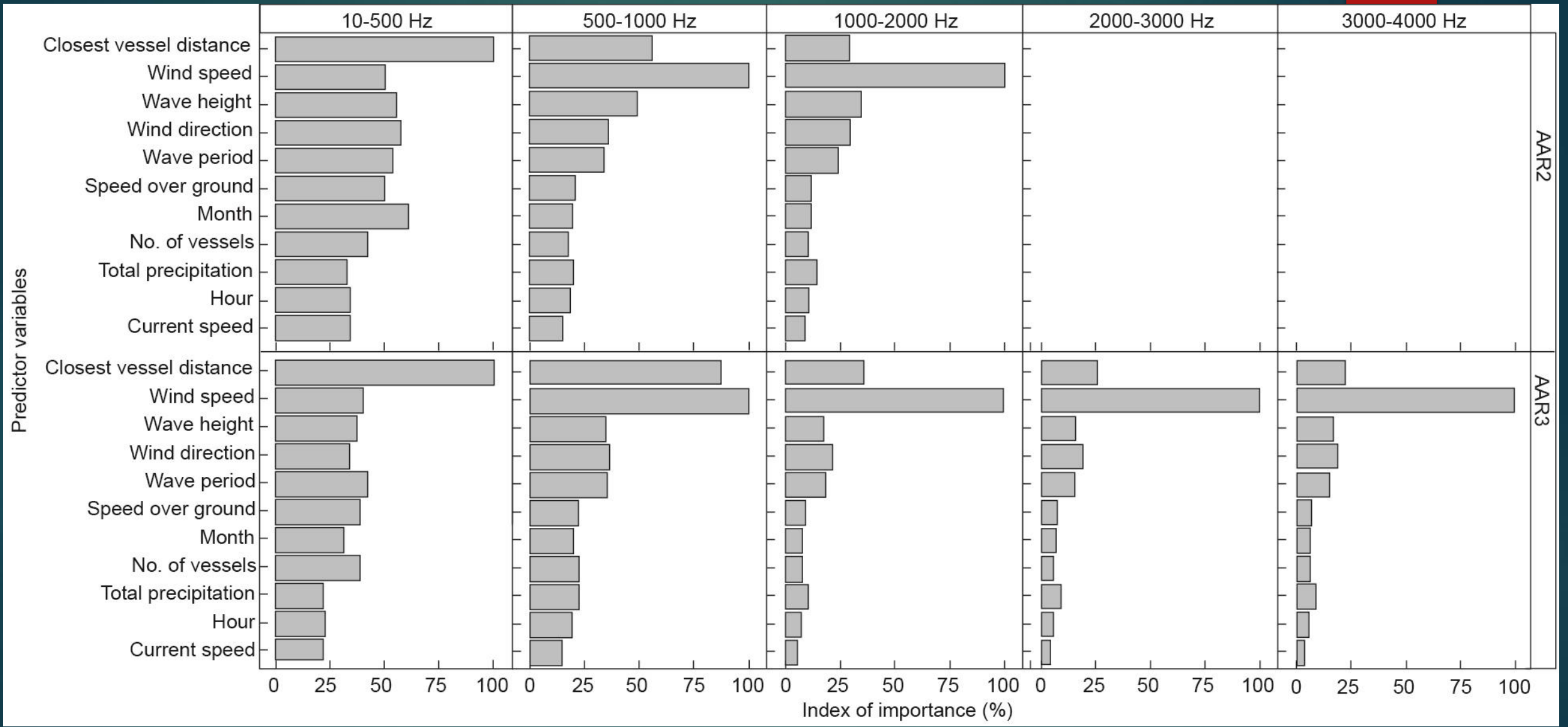
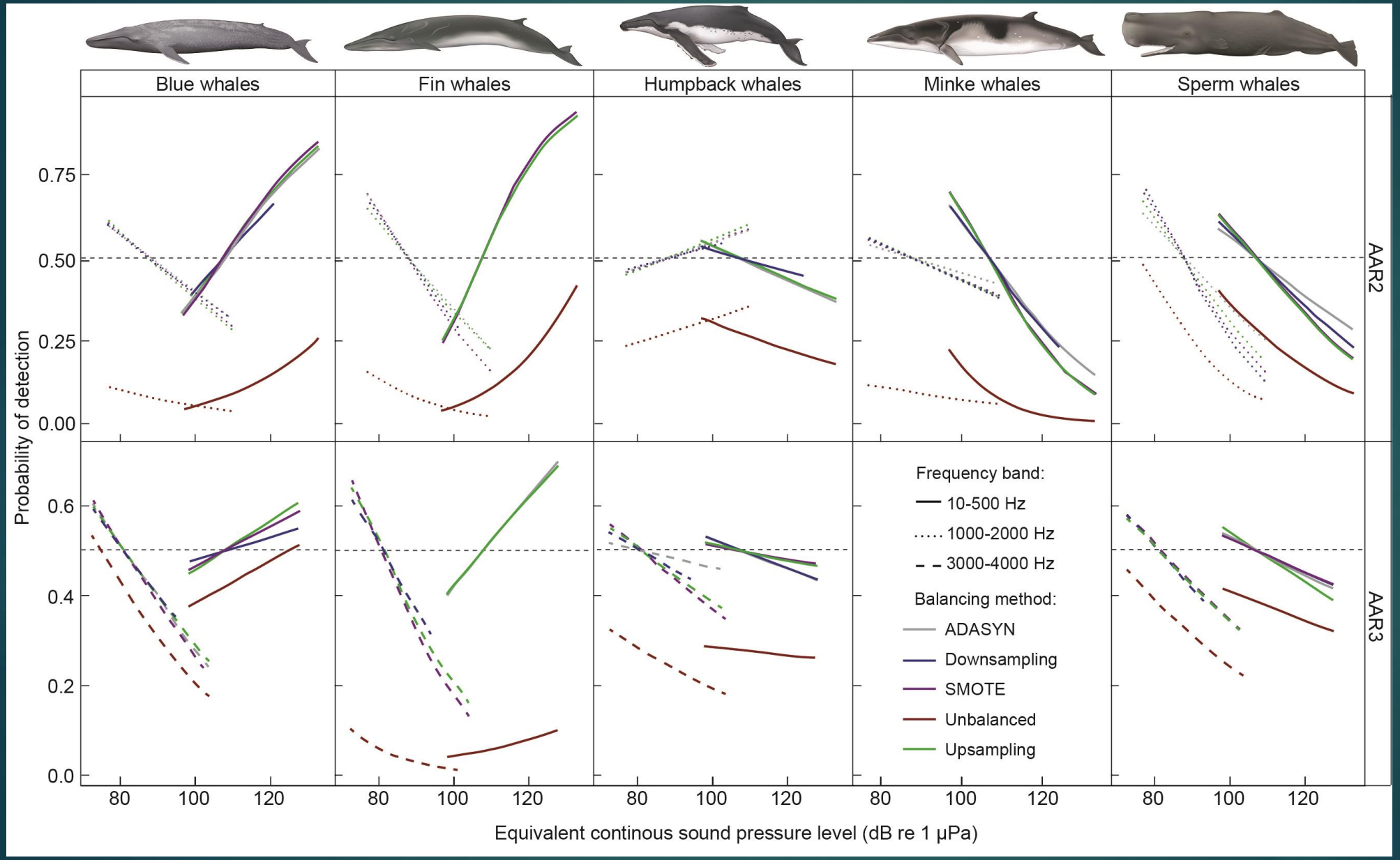
Sources of underwater noise



Shabangu et al. (2022) Whales and underwater noise. Mar Pol Bul

Whale response to underwater noise

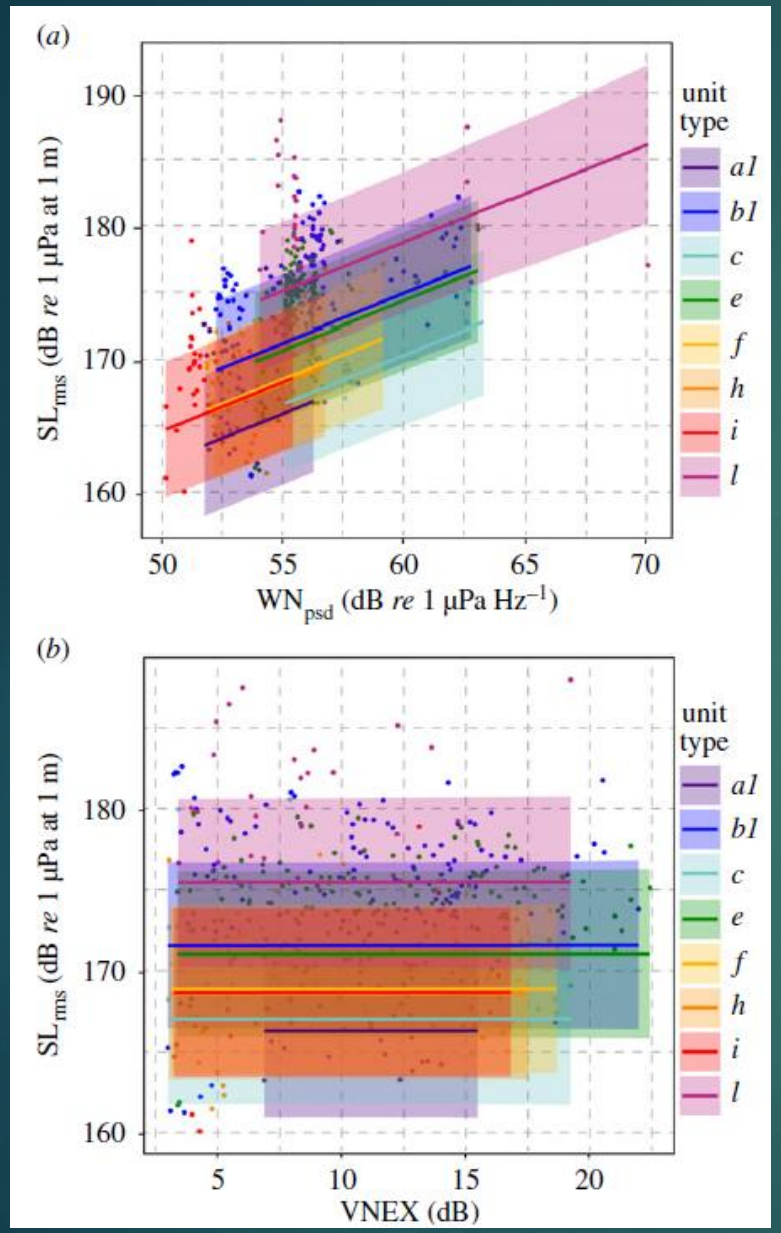


Possible use of the region:

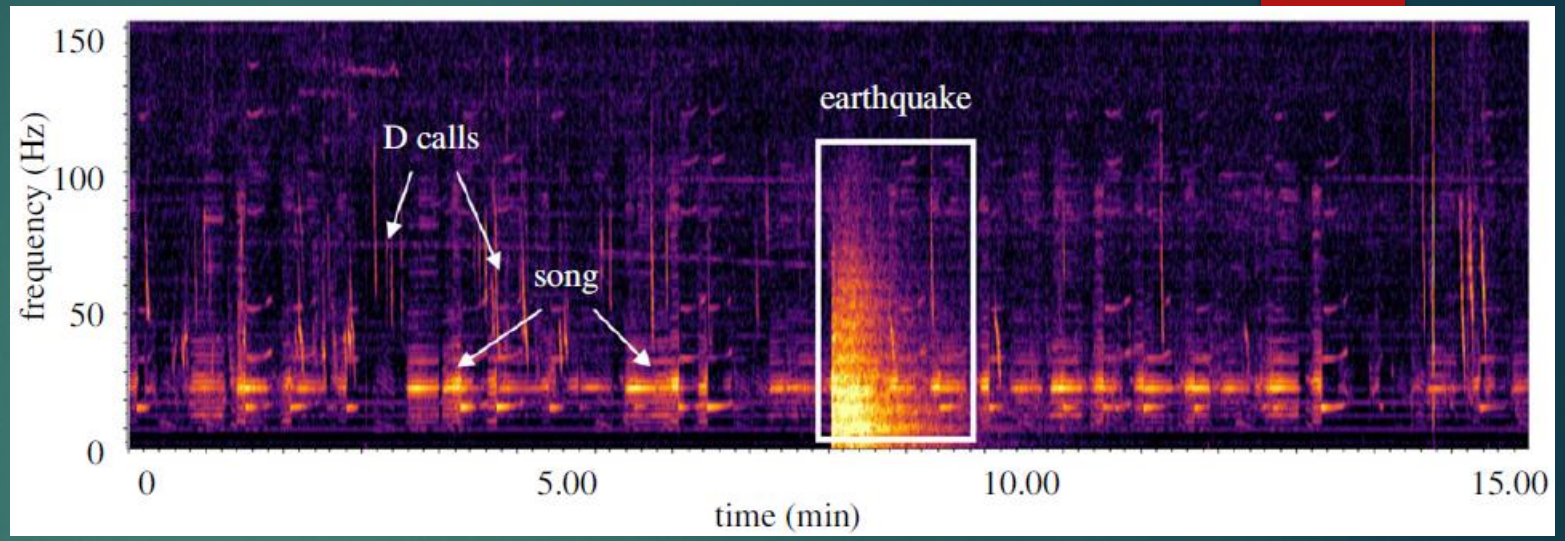
- Migration
- Feeding
- Breeding/mating
- Year-round habitat

Shabangu et al. (2022) Whales and underwater noise. Mar Pol Bul

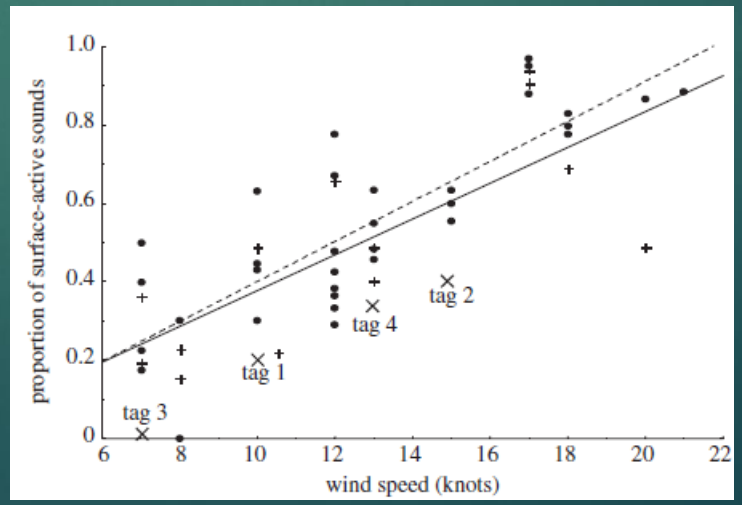
Observations from elsewhere



Girola et al. (2023) Singing humpback whales respond to wind noise, but not to vessel noise. Proc. R. Soc. B

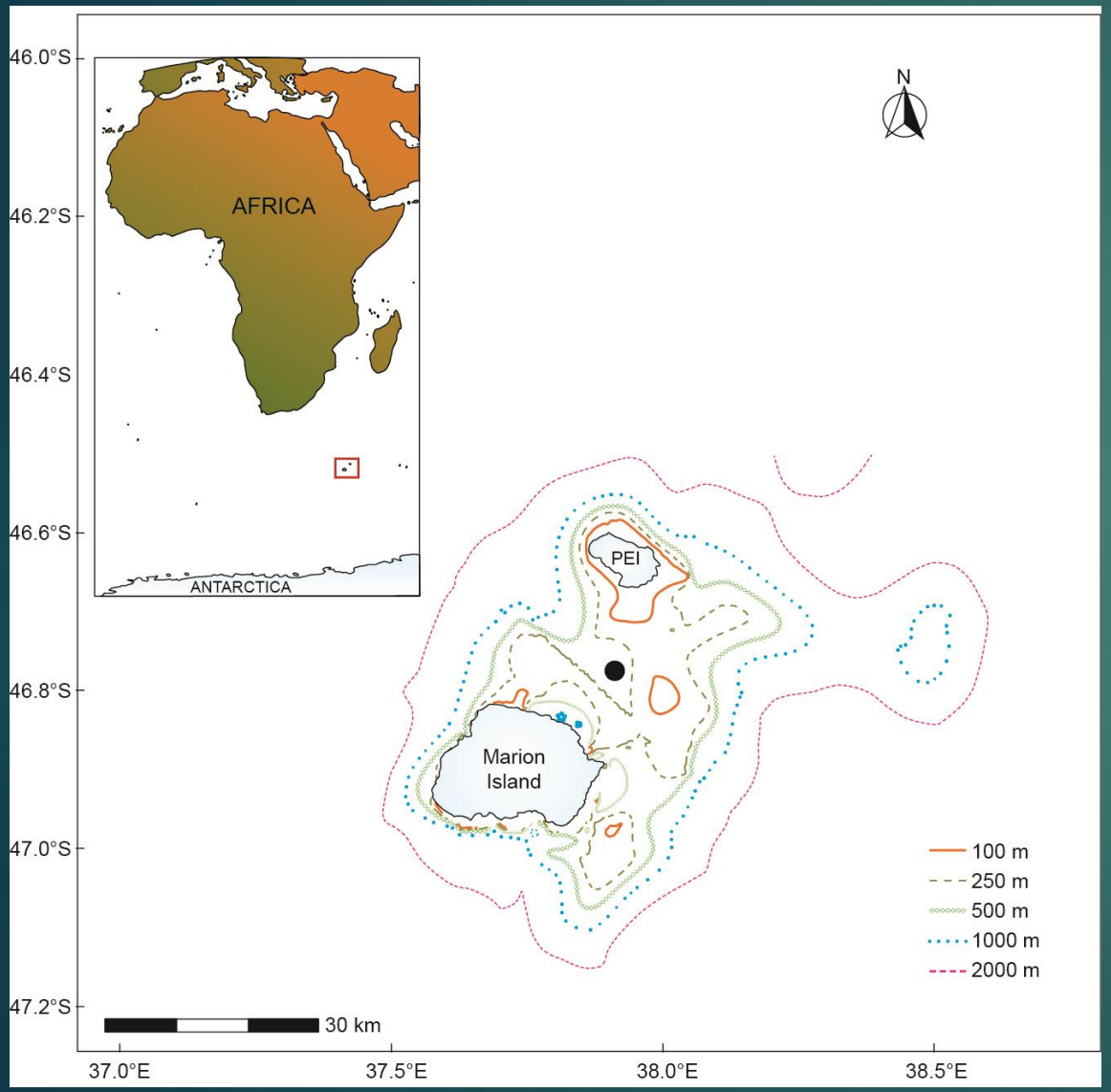


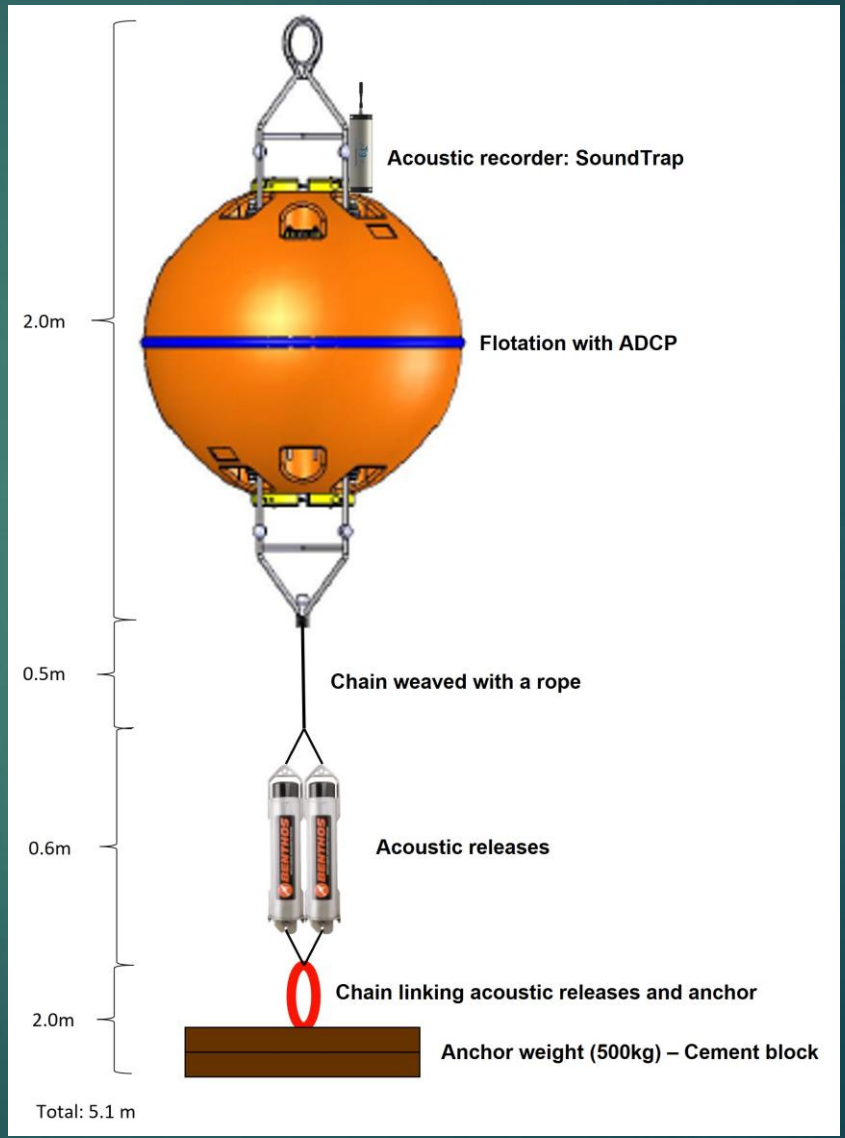
Barlow et al. (2022) Shaken, not stirred- Blue whales show no acoustic response to earthquake events. R. Soc. Open Sci.



Dunlop et al. (2010) Your attention please- increasing ambient noise levels elicits a change in communication behaviour in humpback whales. Proc. R. Soc. B

Sub-Antarctic passive acoustic monitoring

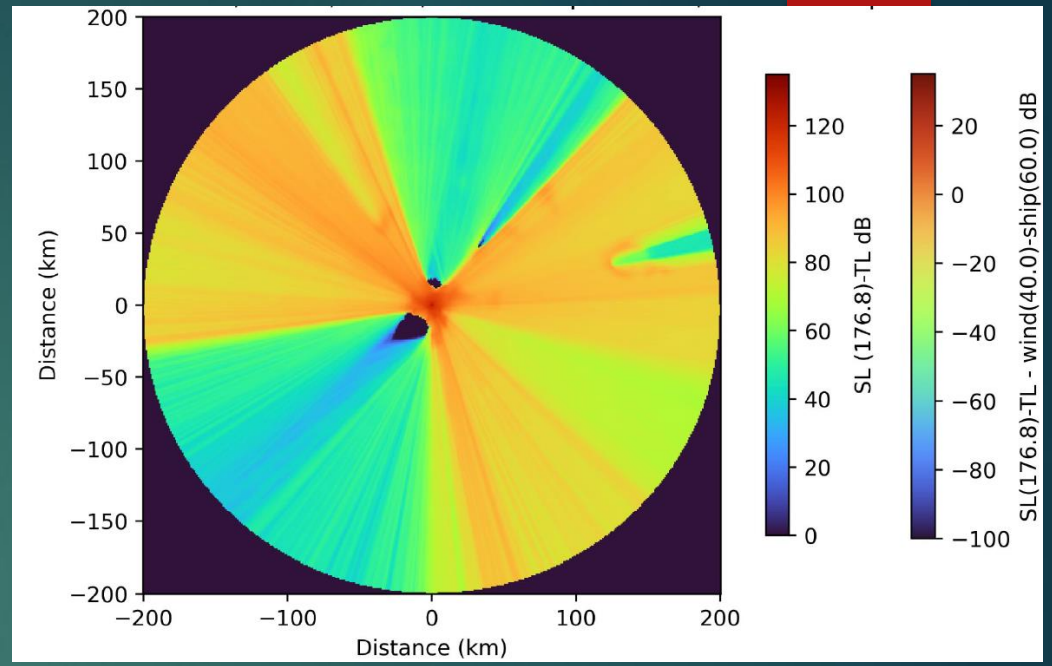


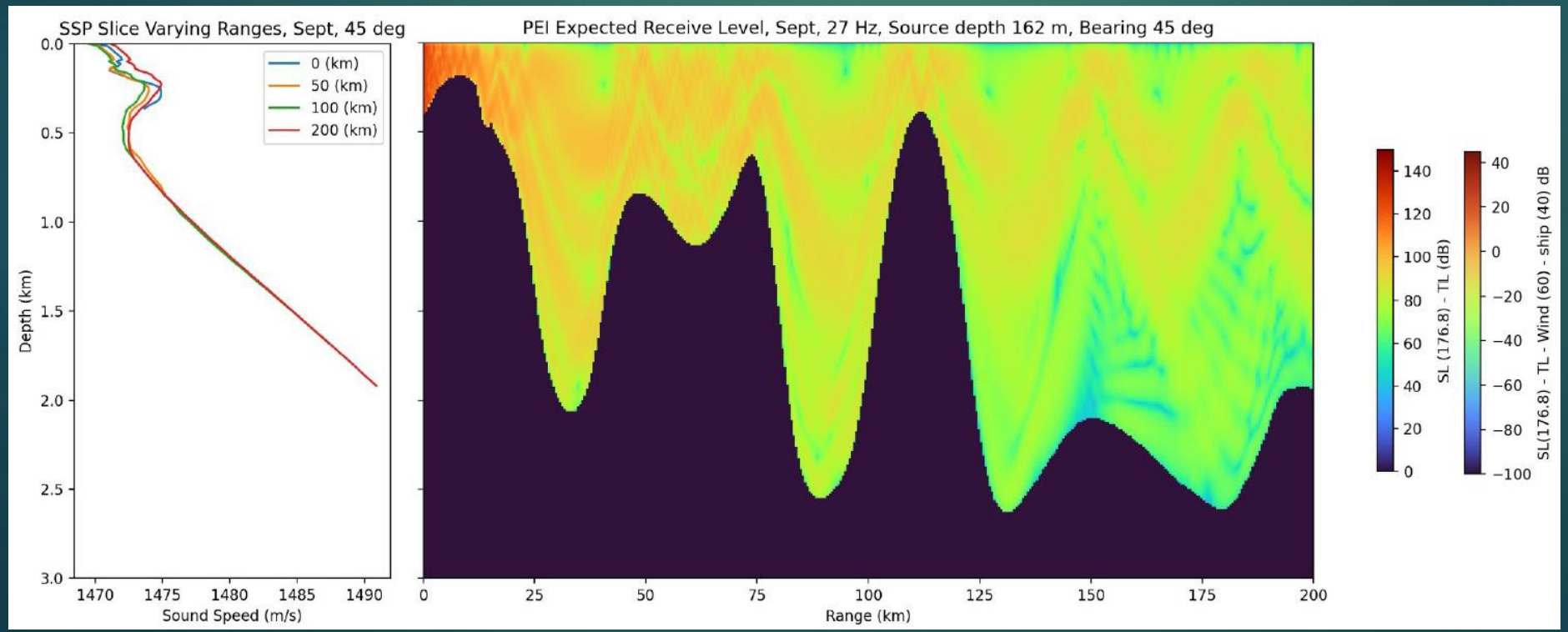


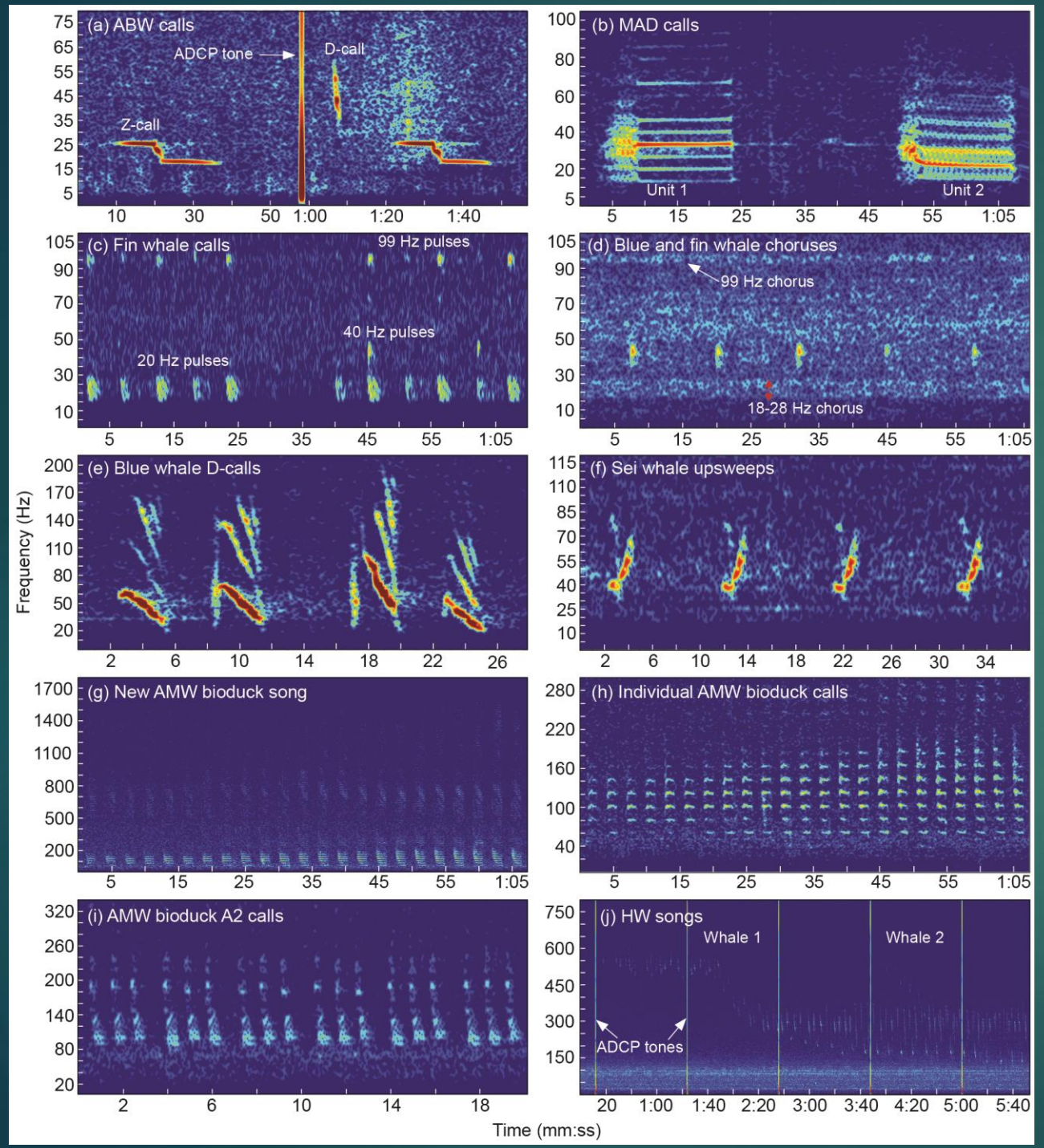
- Water depth: 167 m
- Recorder depth: 162 m
- SR: 96 kHz
- DC: 14 minutes
- Durability: 375 days
- Mid-2021 to date

Sound propagation

- Peregrine, a 3-dimensional parabolic equation (PE) model developed by Applied Ocean Sciences (Heaney and Campbell, 2016)
- Bathymetry influence
- bearing from the sensor
- Temperature and time of year



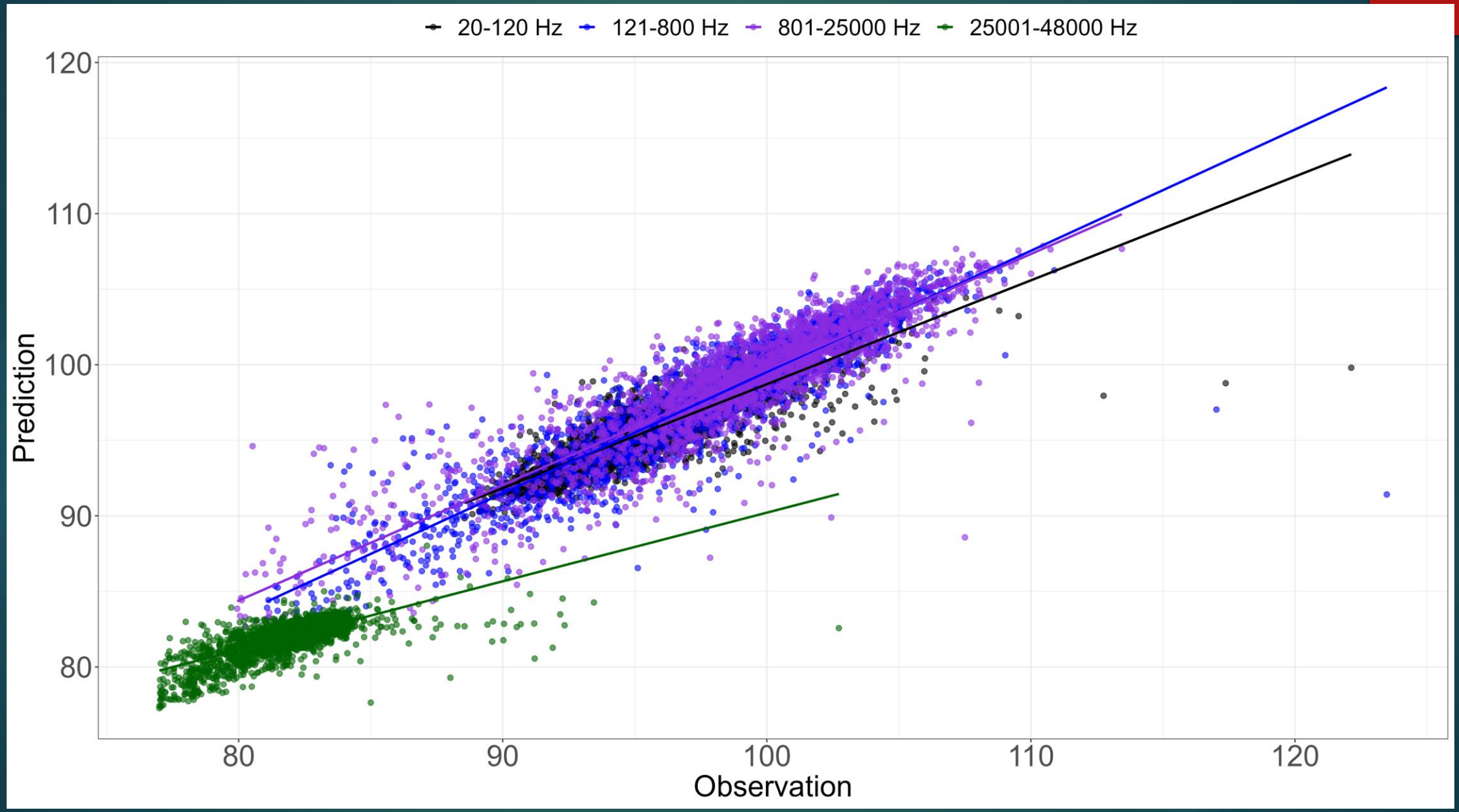




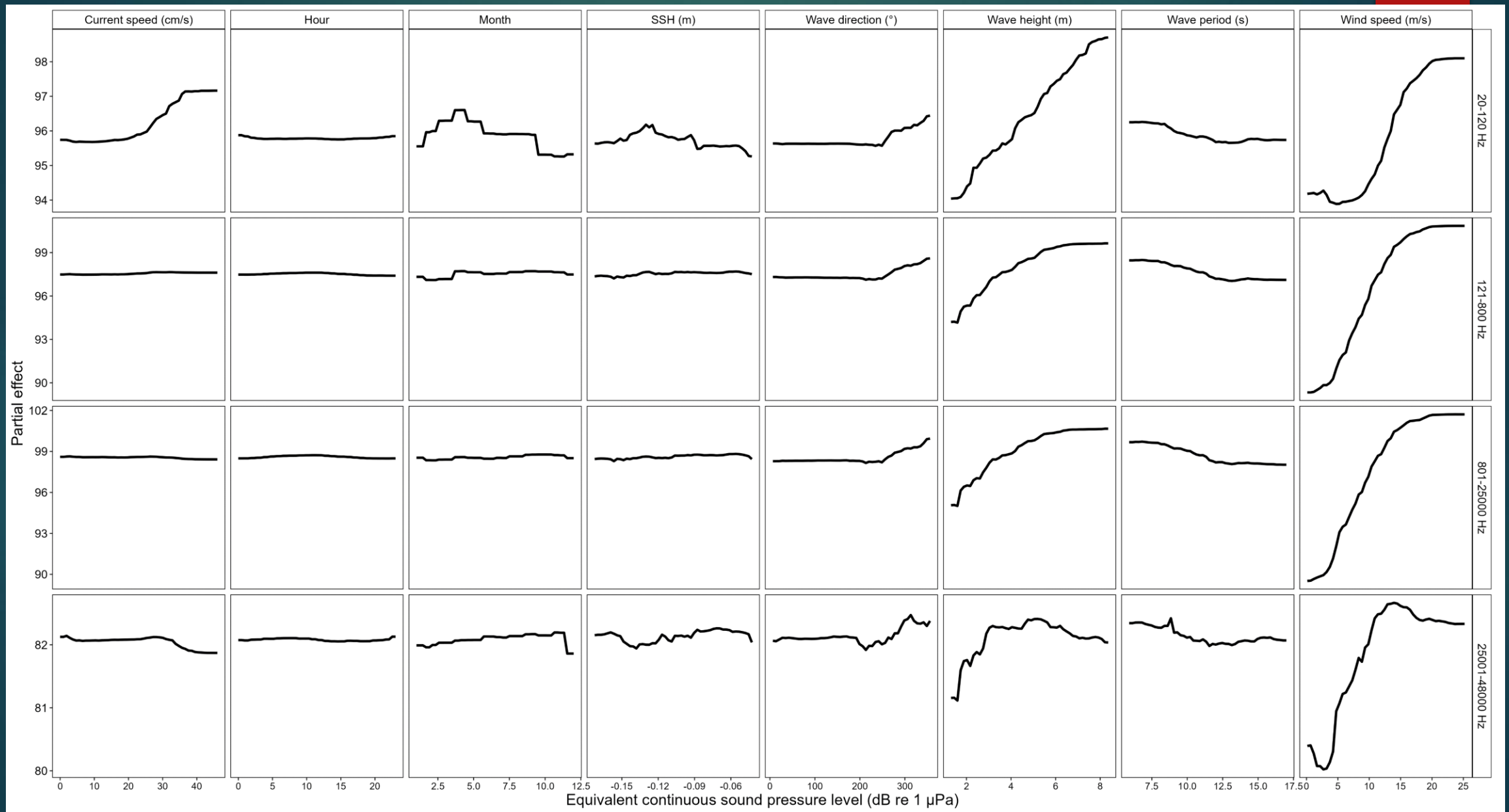
Whales around the PEIs

- Seasonal presence
- Year-round presence
- Feeding
- Overwintering
- Migratory route

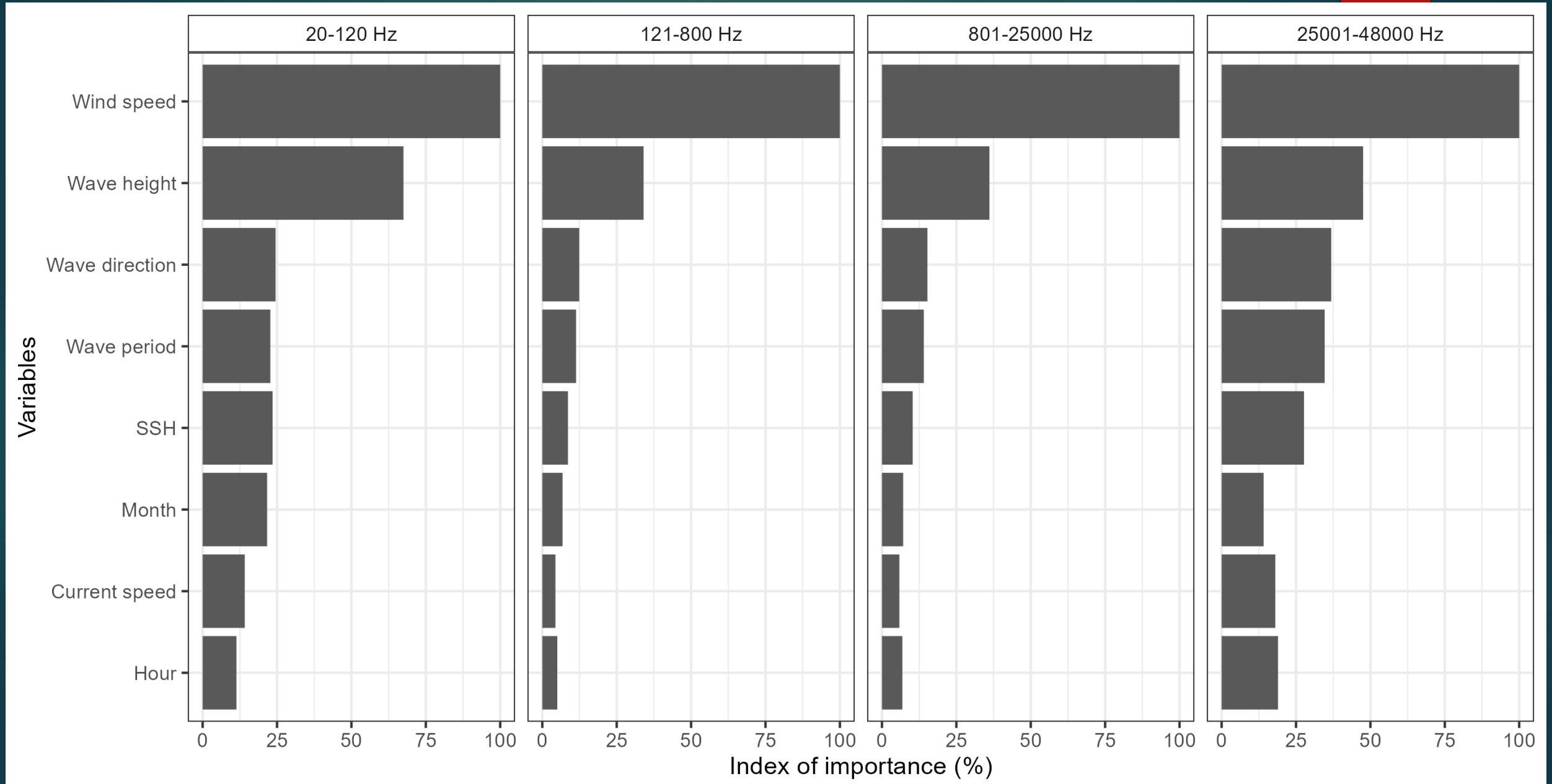
Noise at different frequency bands



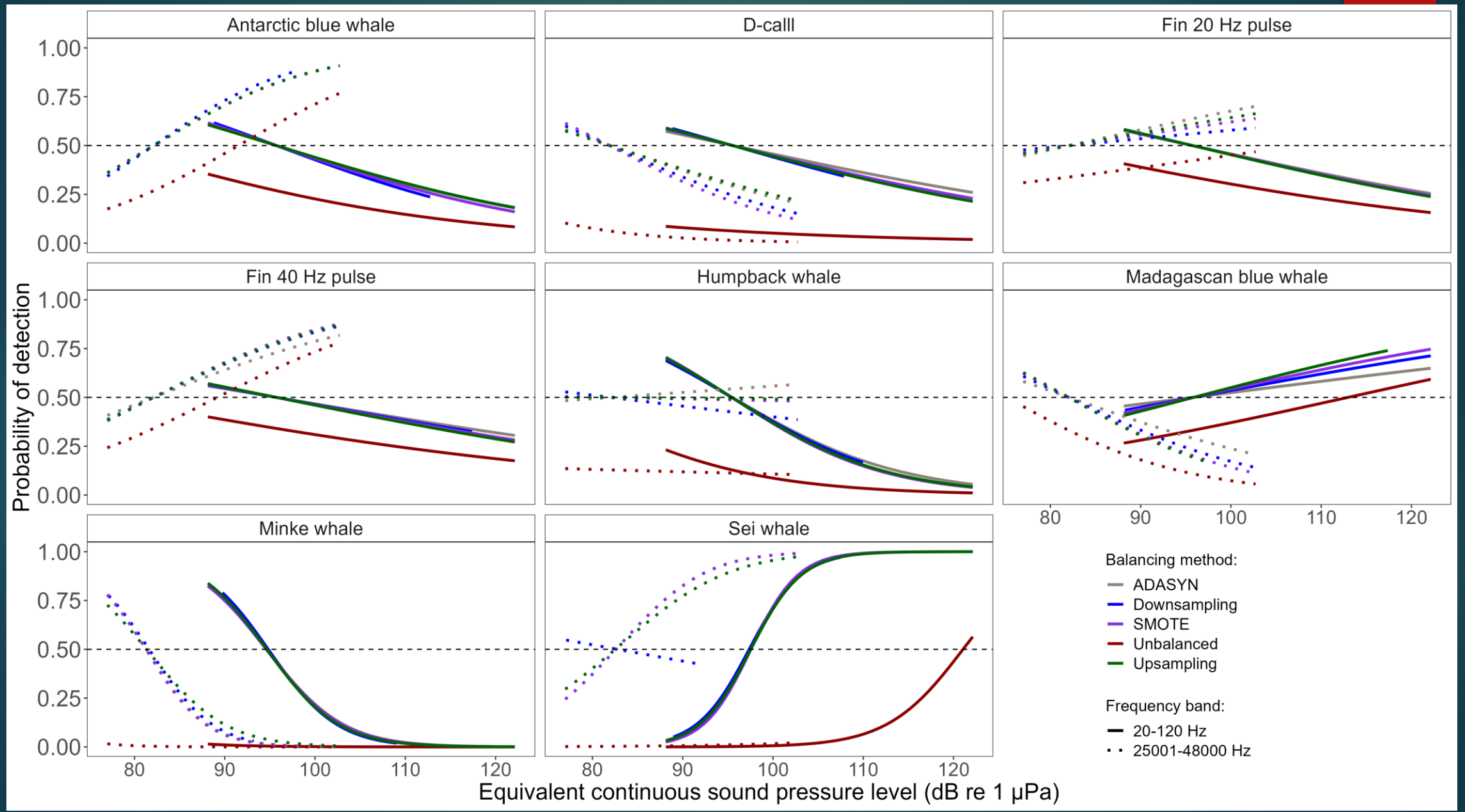
Predictors of underwater noise: PEIs



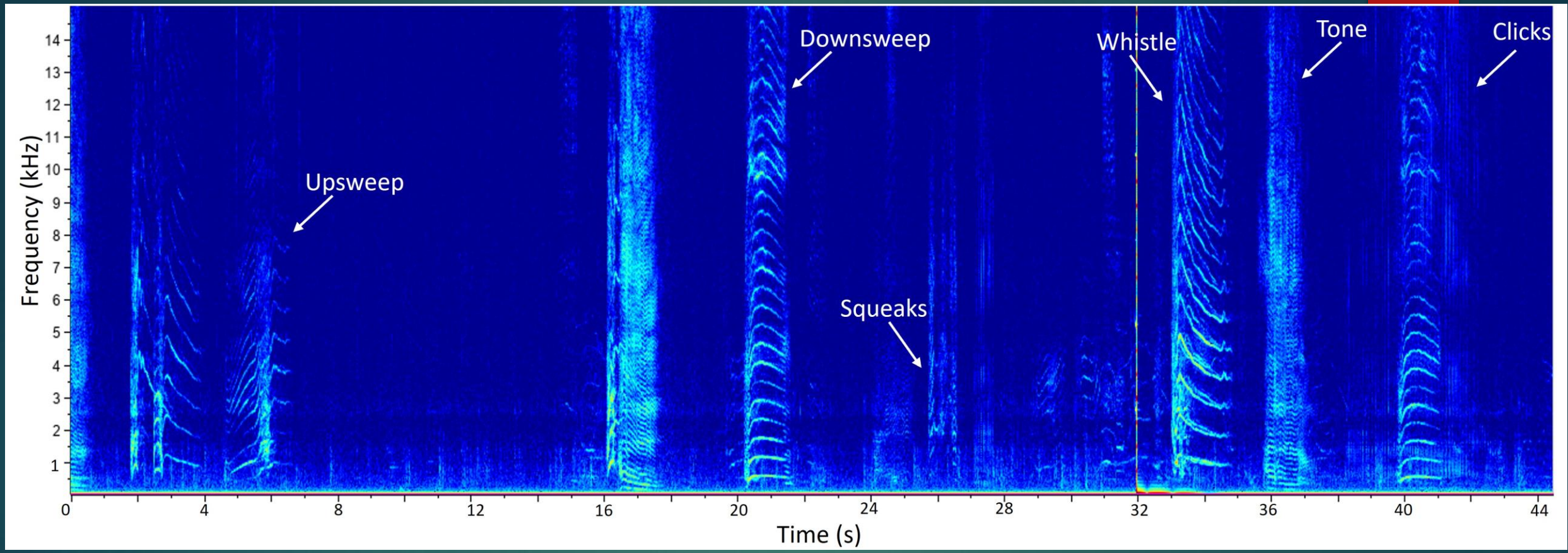
Ranked relative variable importance

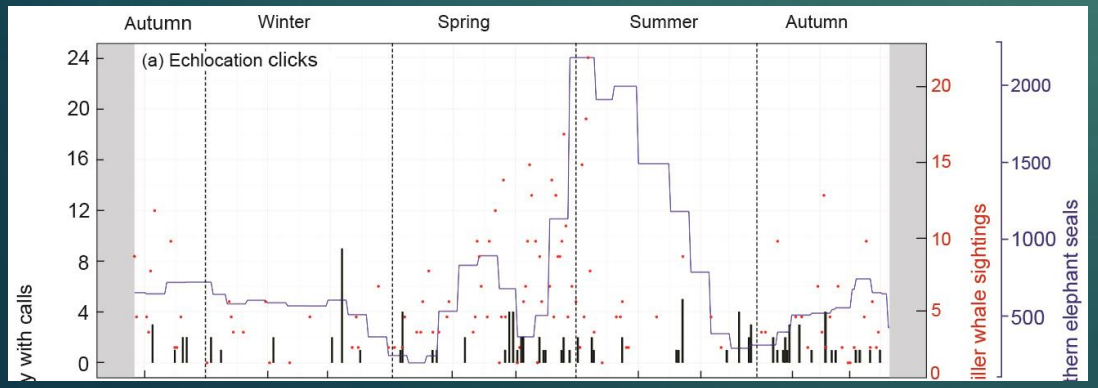


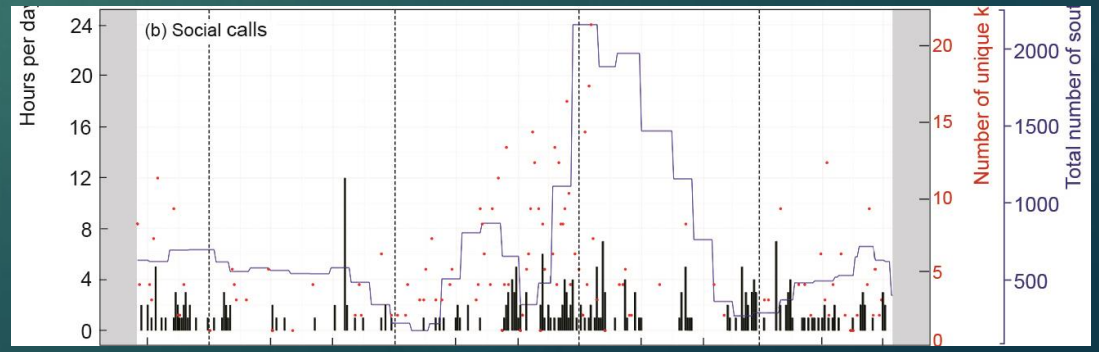
Responses of whales to noise: PEIs



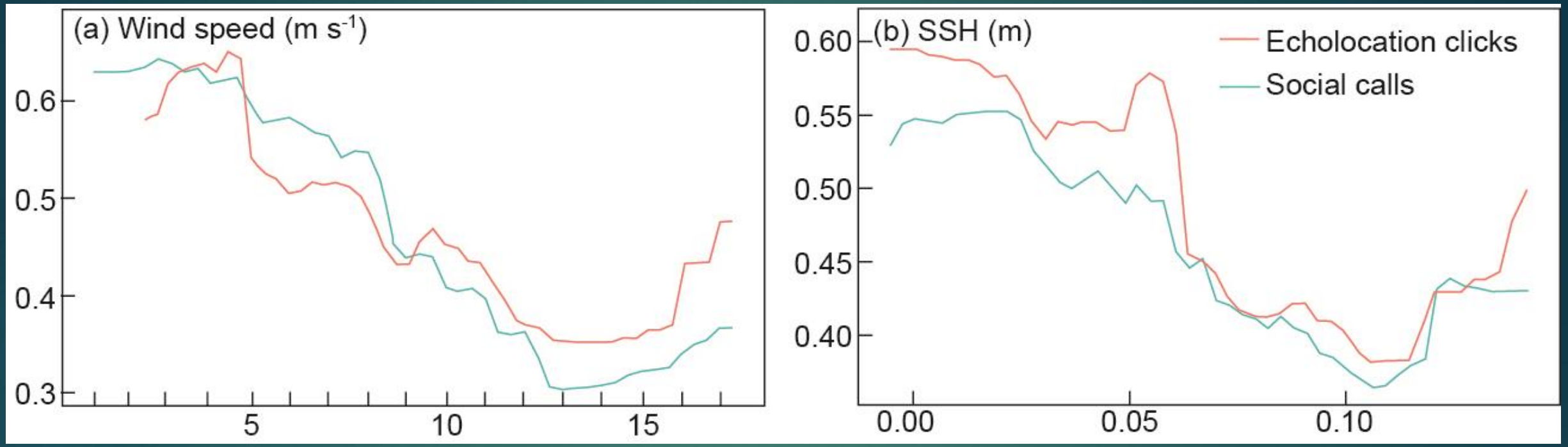
Dolphin response to noise: PEIs killer whales

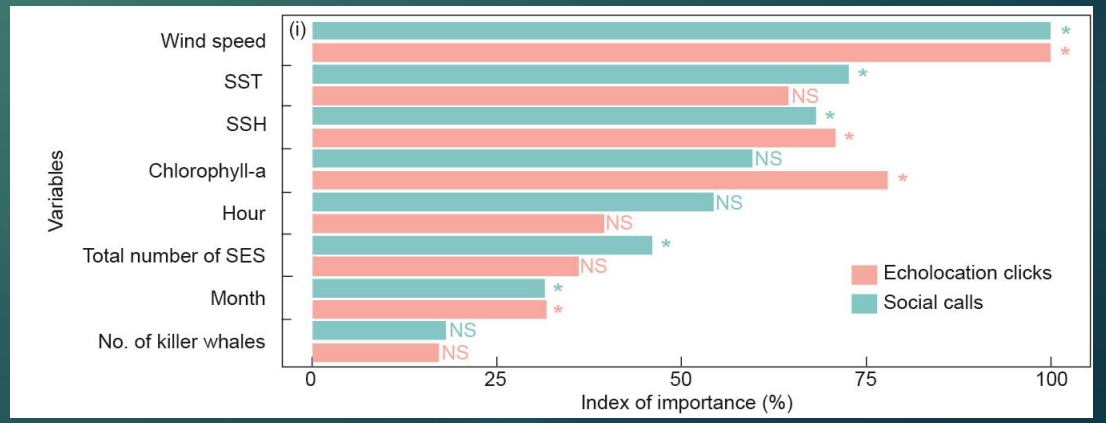




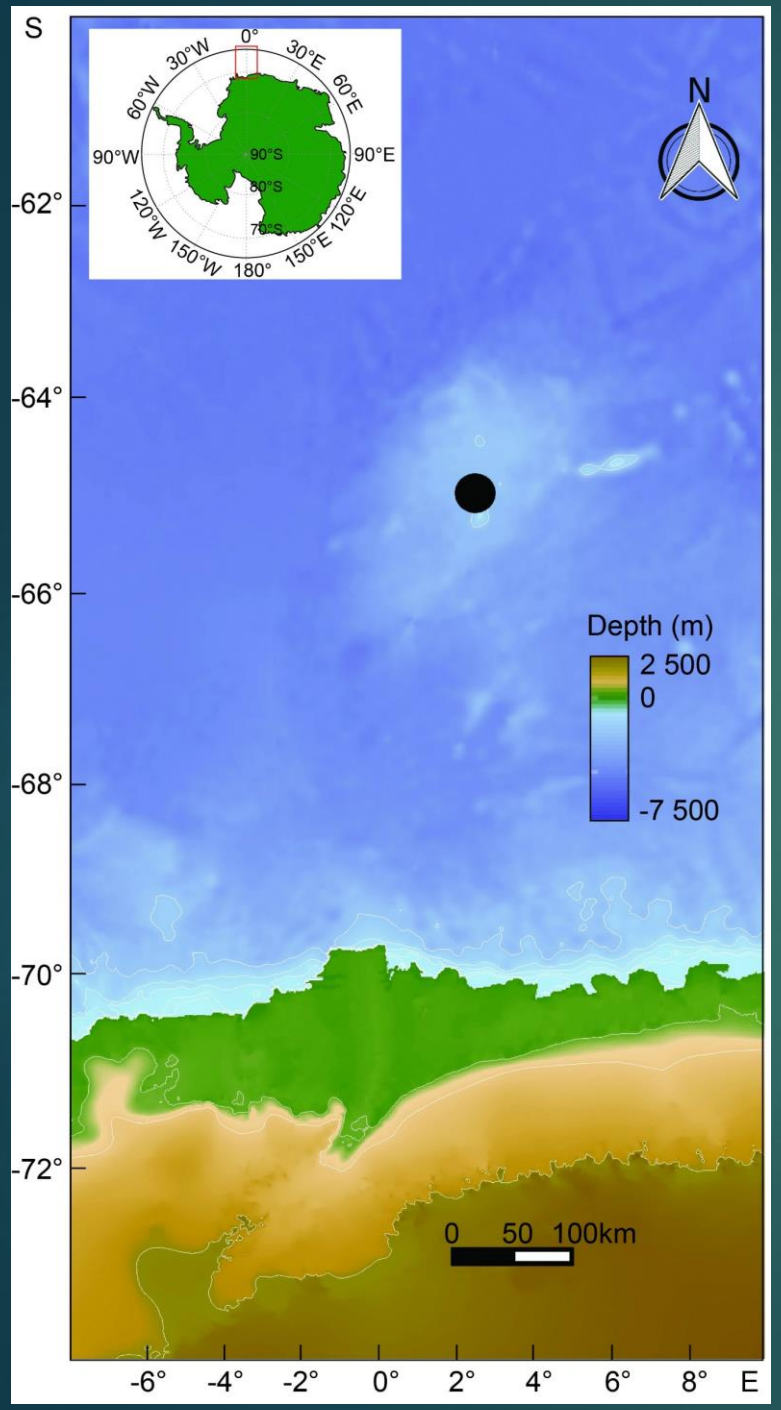


Dolphin response to noise: PEIs killer whales





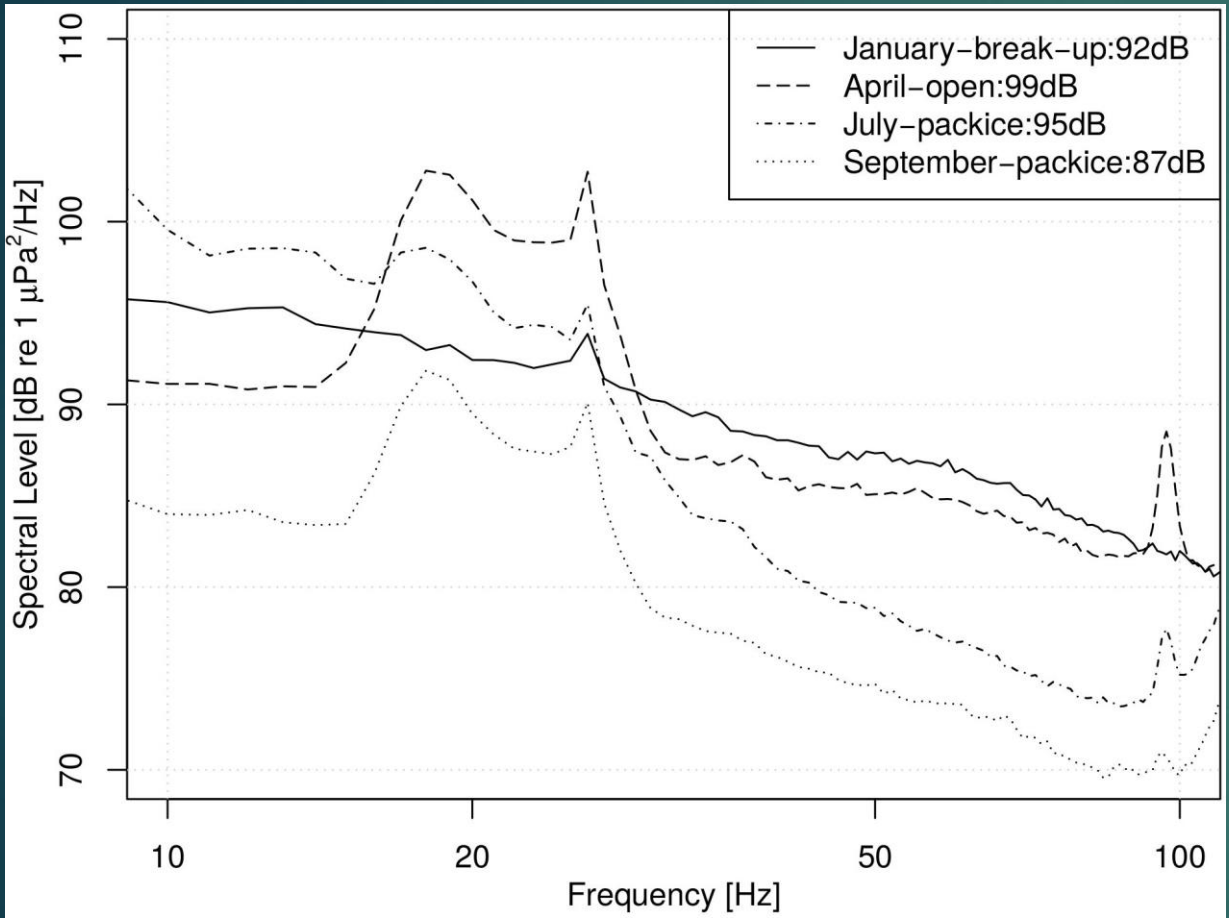

Antarctica

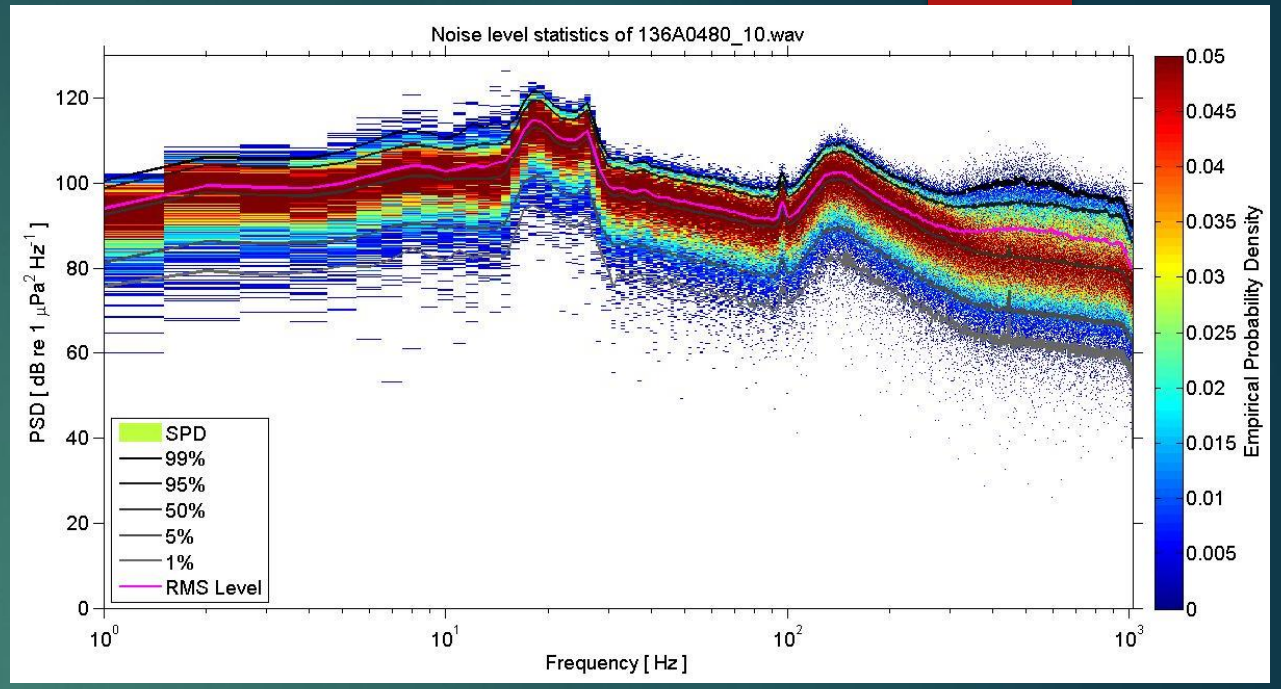


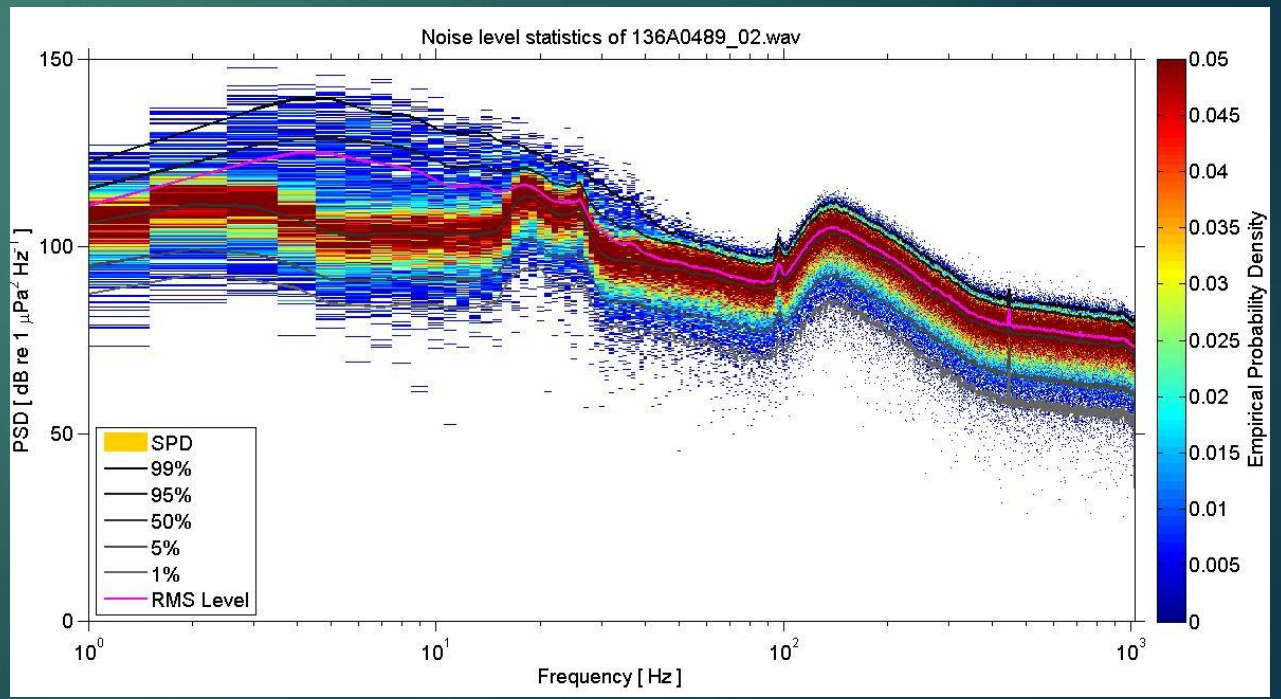
Maud Rise, Antarctica

- Water depth: 1250 m
- Recorder depth: 250 m
- SR: 2 kHz
- DC: 30 minutes
- Durability: 9 months (Jan-Sep 2013)

Antarctic soundscape

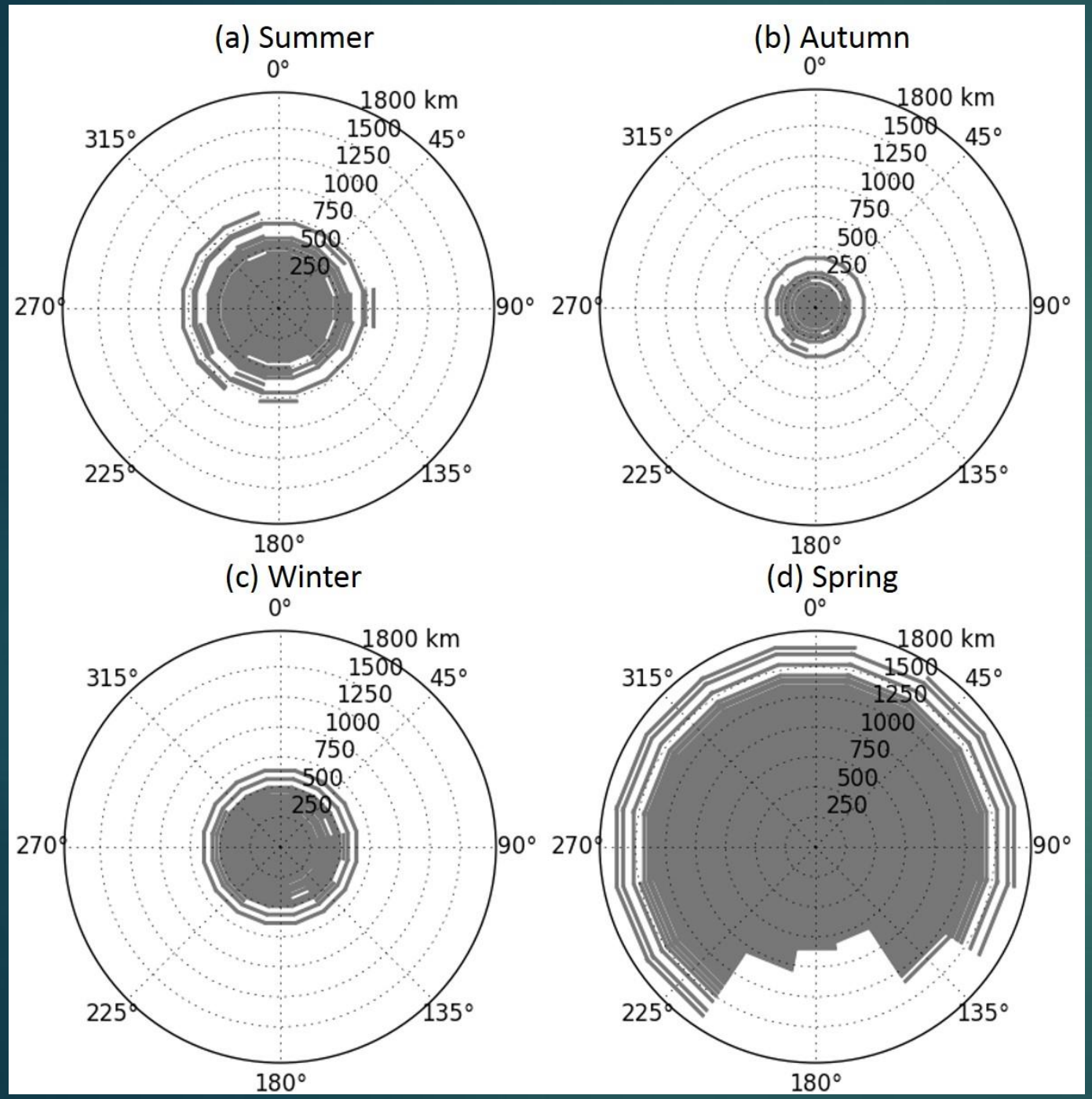


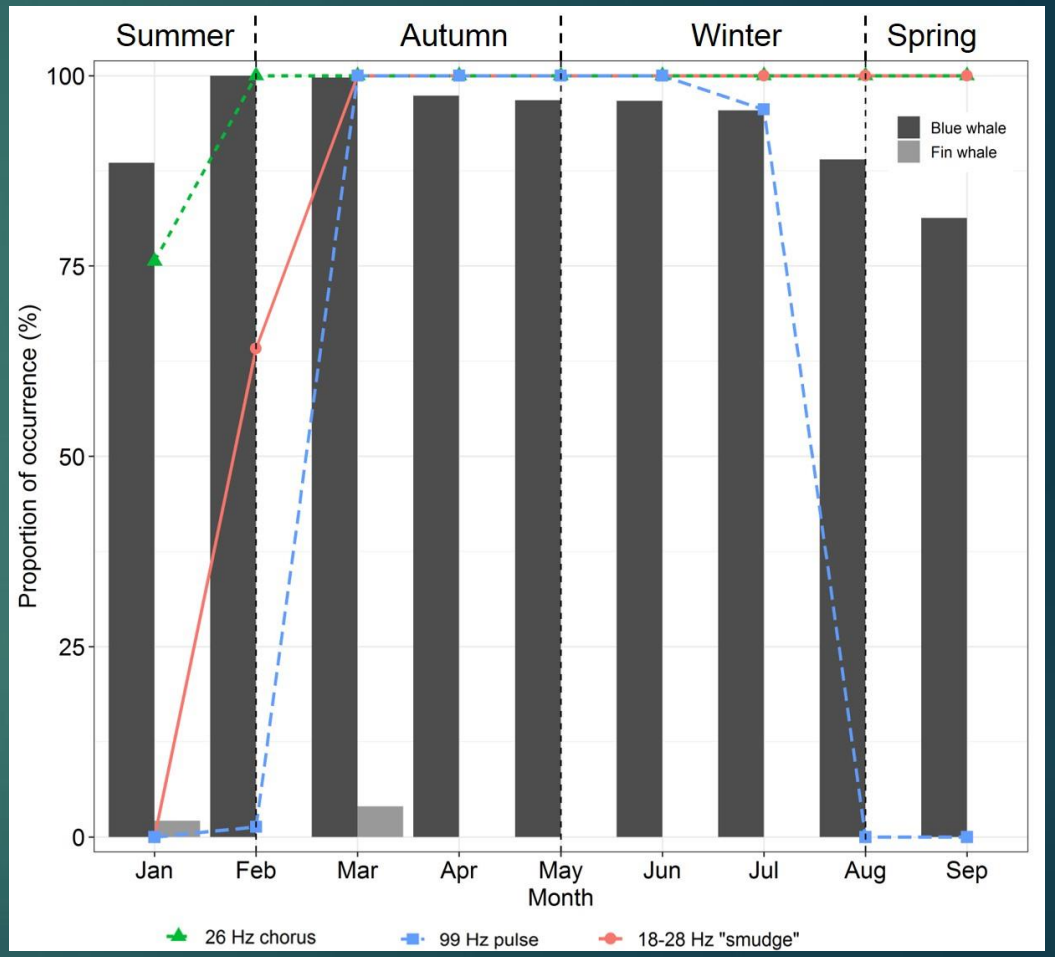




Shabangu et al. (2020) Blue and fin whales under different sea ice condition. End Spec Res

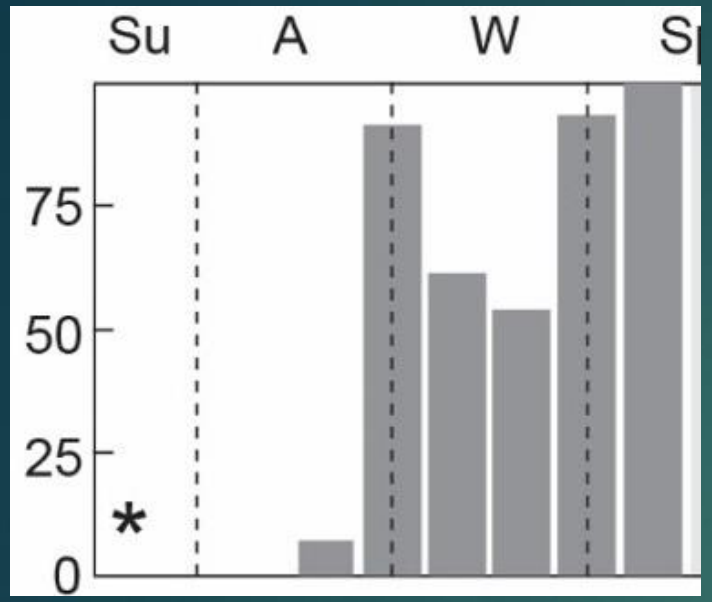
Noise and whale calls



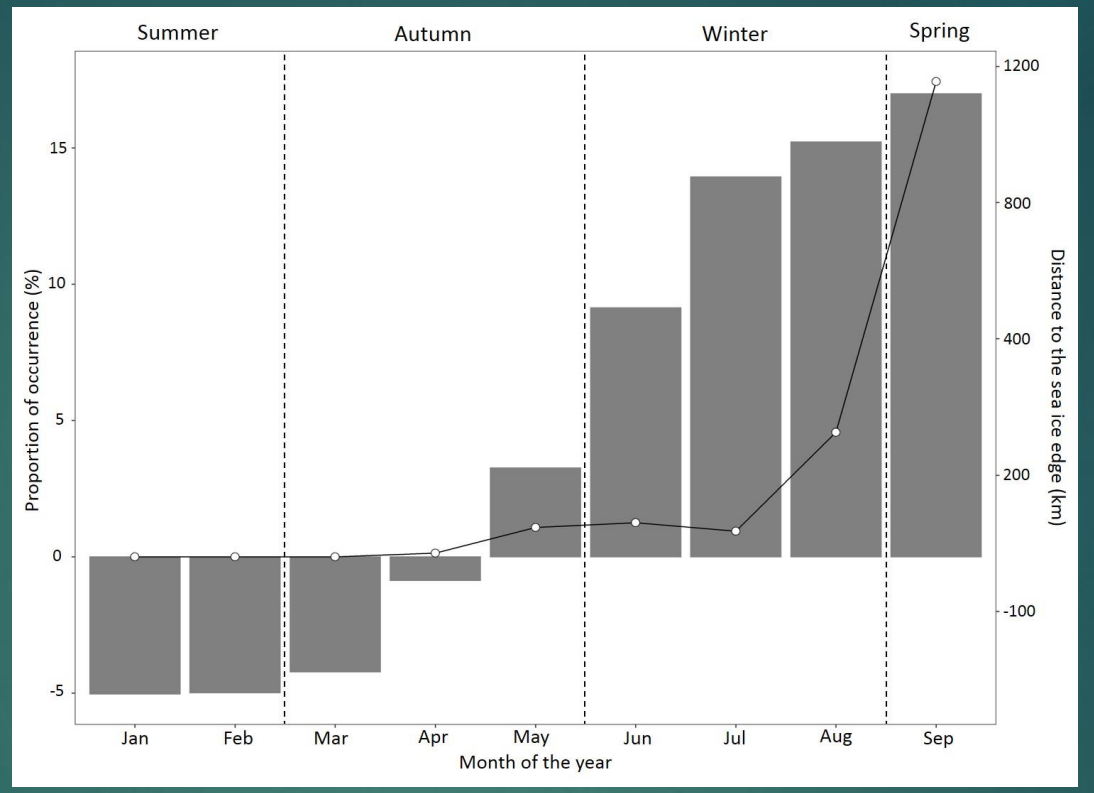


Shabangu et al. (2020) Blue and fin whales under different sea ice condition. Endang Spec Res

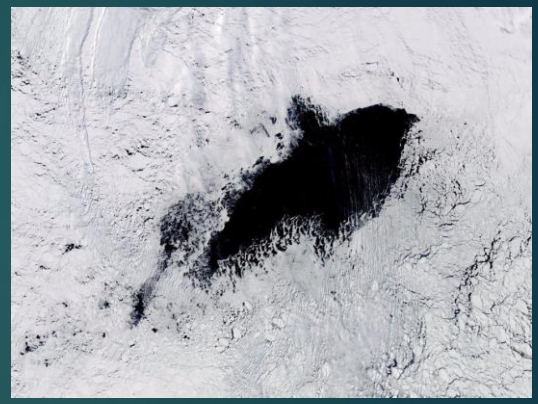
Marine mammal response to noise in Antarctica



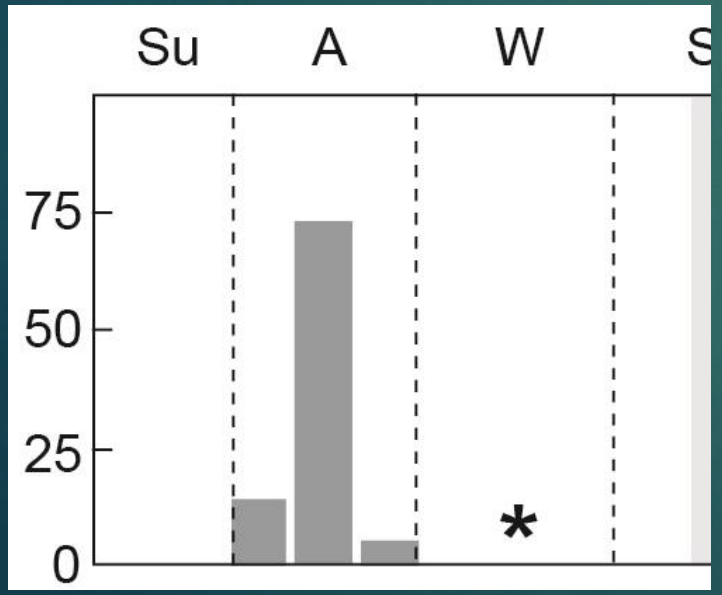
Shabangu et al. (2020) Antarctic minke whales in Antarctic and South African waters. Mar Mam Sci.



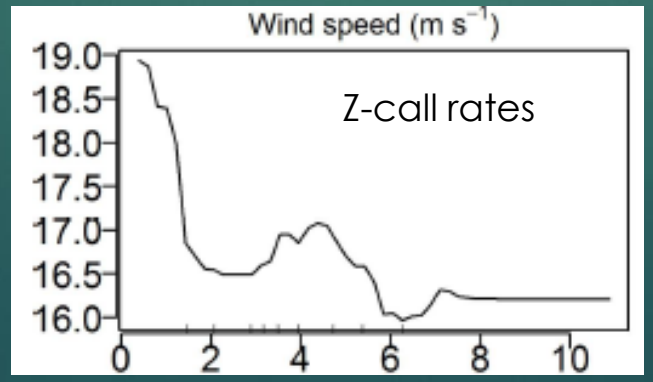
Shabangu and Charif (2021) Crabeater seal acoustic occurrence. Bioacoustics

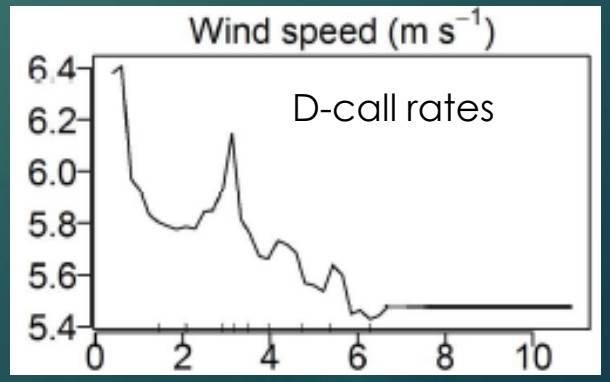


Polynyas around Maud Rise: ~40,000 km^2



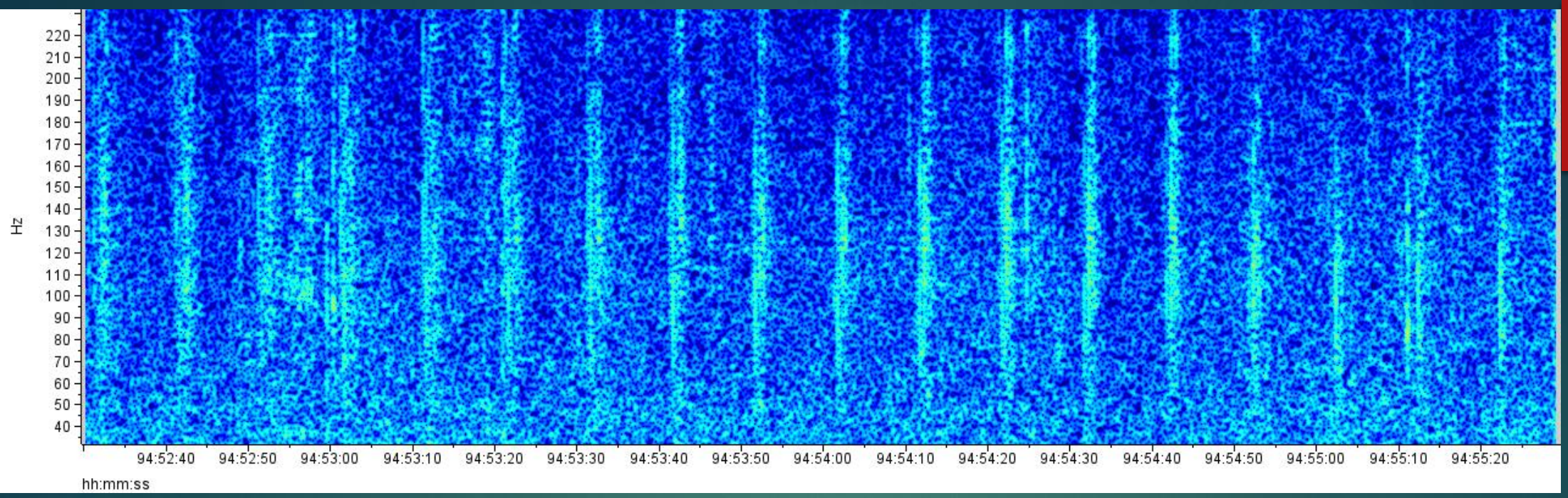
Shabangu and Kowarski (2022) Humpback whale song in Antarctic and South African waters. Front Mar Sci



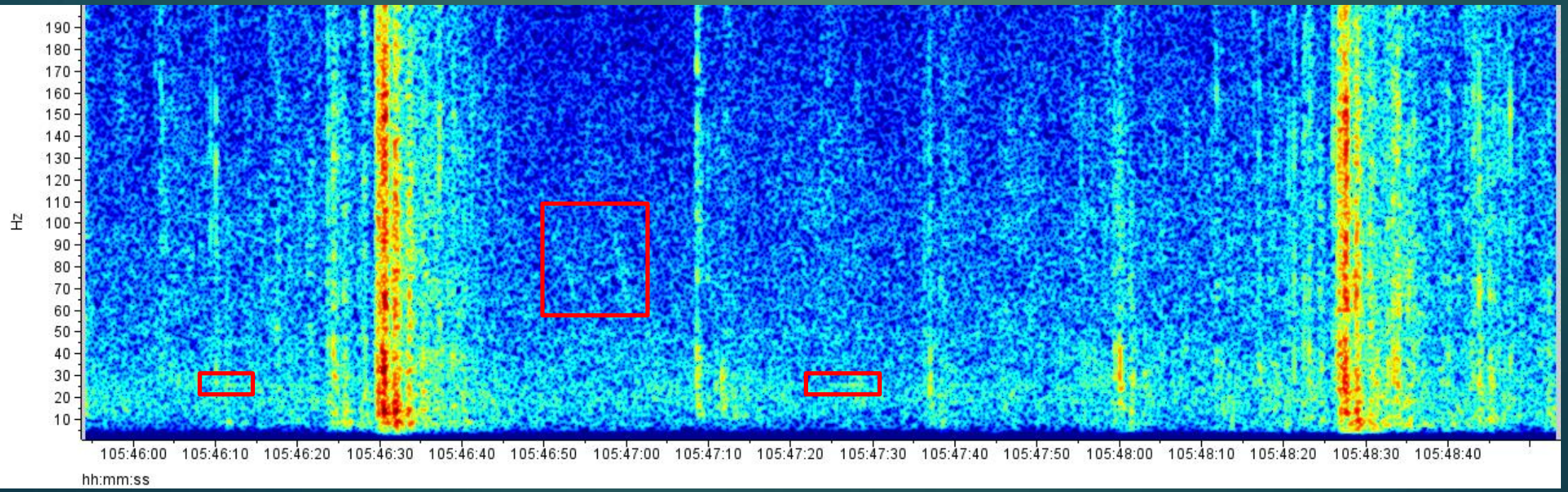


Shabangu et al. (2017) Acoustic occurrence and behaviour of Antarctic blue whales. PlosONE

2022



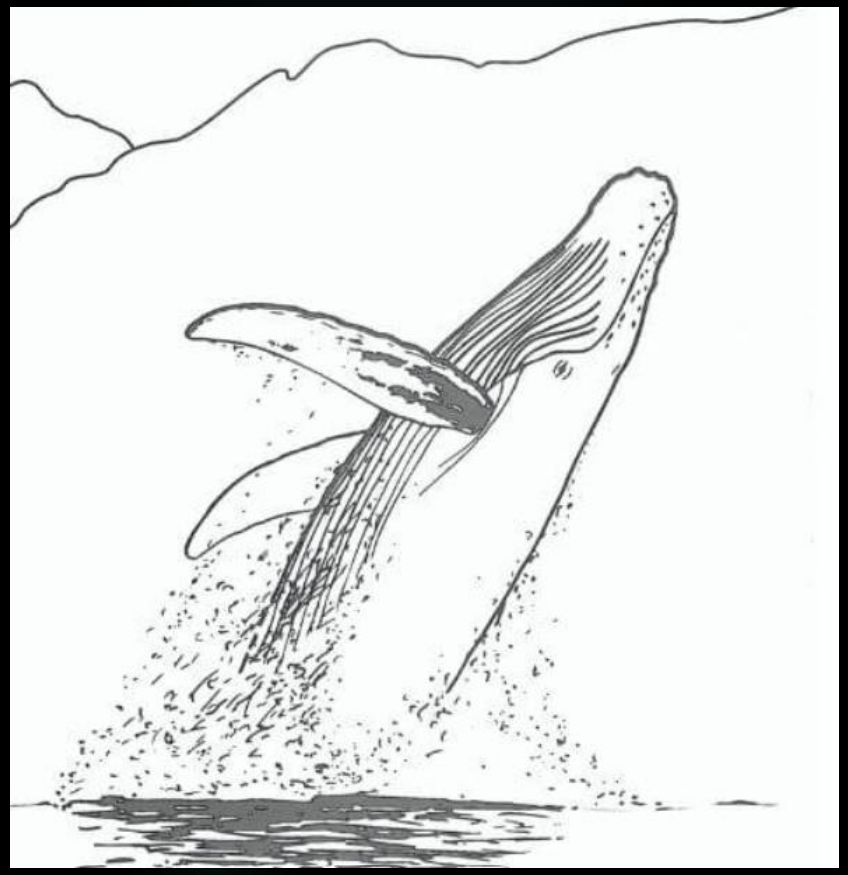
Seismic signals



Sea ice cracking

Summary

- Marine traffic significantly contributed to low frequency noise in SA
- Weather is the major contributor of underwater noise in the soundscape for PEIs and Antarctica
- Species- and region-specific responses to underwater noise
- Biological and physiological processes of whales might be negative impacted by noise
- No seismic airgun signal were detected in SA and PEIs but were detected in Antarctica
- More (long-term) underwater noise research is needed in the Southern Hemisphere



Thank you!

The Society for Marine Mammalogy

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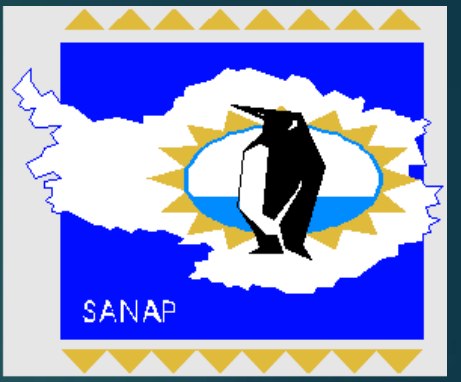

APPLIED OCEAN SCIENCES

The Goldie and David Blanksteen Foundation

International Whaling Commission

TheCornellLab of Ornithology
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