Eavesdropping at the speed of light

Distributed acoustic sensing of baleen whales

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June 13th, 2023

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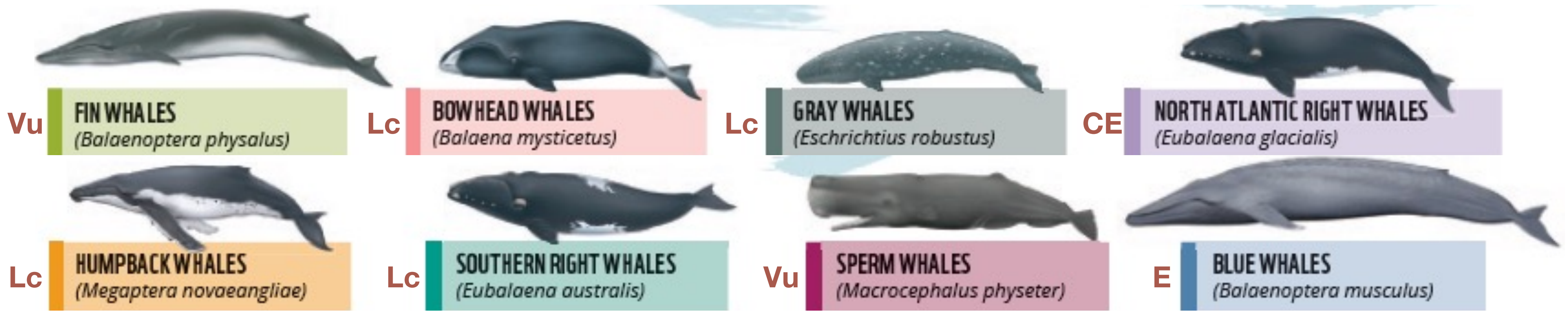
It all starts with a world map



- [WWF report] Johnson et al. (2022). Protecting Blue Corridors - Challenges and solutions for migratory whales navigating national and international seas. Zenodo. DOI: 10.5281/zenodo.6196131

Distributed acoustic sensing & water born sources

RESEARCH ARTICLE | SEPTEMBER 22, 2021

Noise Levels and Signals Observed on Submarine Fibers in the Canary Islands Using DAS

Arantza Ugalde; Carlos Becerril; Antonio Villaseñor; César R. Ranero; María R. Fernández-Ruiz; Sonia Martin-Lopez; Miguel González-Herráez; Hugo F. Martins

Seismological Research Letters (2022) 93 (1): 351–363.

https://doi.org/10.1785/0220210049 Article history

Article | Open Access | Published: 02 February 2021

Detection of hydroacoustic signals on a fiber-optic submarine cable

Hiroyuki Matsumoto, Eiichiro Araki, Toshinori Kimura, Gou Fujie, Kazuya Shiraishi, Takashi Tonegawa, Koichiro Obana, Ryuta Arai, Yuka Kaiho, Yasuyuki Nakamura, Takashi Yokobiki, Shuichi Kodaira, Narumi Takahashi, Robert Ellwood, Victor Yartsev & Martin Karrenbach

Scientific Reports 11, Article number: 2797 (2021) | Cite this article

3024 Accesses | 2 Citations | Metrics

Airguns

frontiers | Frontiers in Marine Science

ORIGINAL RESEARCH
published: 05 July 2022
doi: 10.3389/fmars.2022.901348

Eavesdropping at the Speed of Light: Distributed Acoustic Sensing of Baleen Whales in the Arctic

Léa Bouffaut[1,2,3], Kittinat Taweesintananon[1,2,4], Hannah J. Kriesell[1,2], Robin A. Rørstadbotnen[1,2], John R. Potter[1,2], Martin Landrø[1,2], Ståle E. Johansen[2,5], Jan K. Brenne[2,6], Aksel Haukanes[6], Olaf Schjelderup[7] and Frode Storvik[7]*

frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 28 April 2023
DOI 10.3389/fmars.2023.1130898

Simultaneous tracking of multiple whales using two fiber-optic cables in the Arctic

Robin André Rørstadbotnen[1,2*], Jo Eidsvik[2,3], Léa Bouffaut[4], Martin Landrø[1,2], John Potter[1,2], Kittinat Taweesintananon[1,2,5], Ståle Johansen[1,2,6], Frode Storevik[2,7], Joacim Jacobsen[2,8], Olaf Schjelderup[2,7], Susann Wienecke[2,8], Tor Arne Johansen[9], Bent Ole Ruud[9], Andreas Wuestefeld[2,10] and Volker Oye[2,10]

Home > The Journal of the Acoustical Society of America > Volume 149, Issue 4 > 10.1121/10.0004129

Full • Submitted: 19 June 2020 • Accepted: 15 March 2021 • Published Online: 14 April 2021

Preliminary assessment of ship detection and trajectory evaluation using distributed acoustic sensing on an optical fiber telecom cable

The Journal of the Acoustical Society of America 149, 2615 (2021); https://doi.org/10.1121/10.0004129

Diane Rivet[1,a)], Benoit de Cacqueray[2], Anthony Sladen[1], Aurélien Roques[3], and Gaëtan Calbris[4]

Shore station

Article | Open Access | Published: 10 November 2022

Sensing whales, storms, ships and earthquakes using an Arctic fibre optic cable

Martin Landrø, Léa Bouffaut, Hannah Joy Kriesell, John Robert Potter, Robin André Rørstadbotnen, Kittinat Taweesintananon, Ståle Emil Johansen, Jan Kristoffer Brenne, Aksel Haukanes, Olaf Schjelderup & Frode Storvik

Scientific Reports 12, Article number: 19226 (2022) | Cite this article

2997 Accesses | 30 Altmetric | Metrics

No Access | GEOPHYSICS | Volume 86, Issue 5 Published: 18 Aug 2021

Distributed acoustic sensing for near-surface imaging using submarine telecommunication cable: A case study in the Trondheimsfjord, Norway

Check for updates

Authors:

Kittinat Taweesintananon, Martin Landrø, Jan Kristoffer Brenne, and Aksel Haukanes

https://doi.org/10.1190/geo2020-0834.1

Airguns

Home > JASA Express Letters > Volume 3, Issue 2 > 10.1121/10.0017104

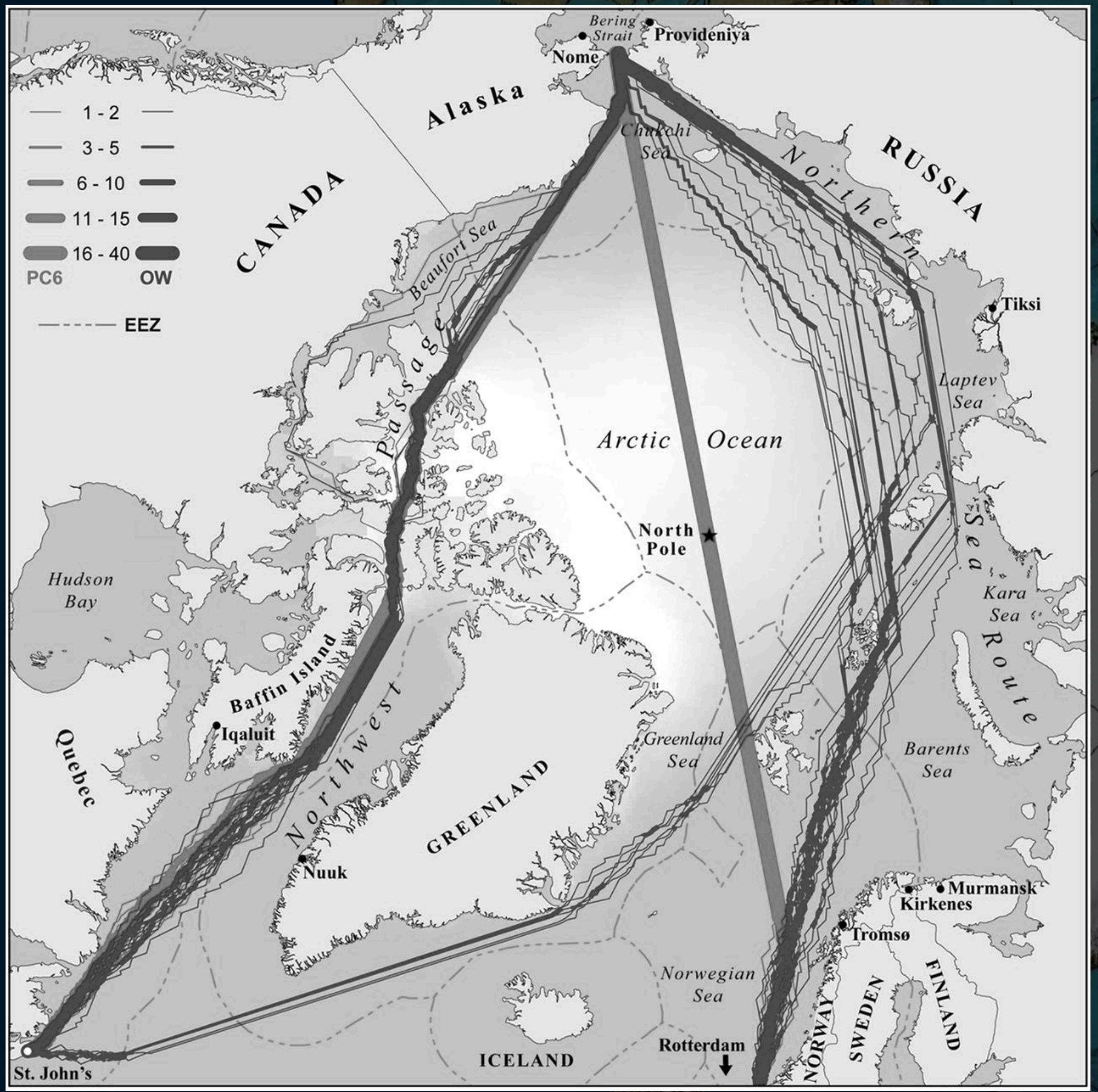
Open • Submitted: 18 October 2022 • Accepted: 13 January 2023 • Published Online: 02 February 2023

Distributed acoustic sensing recordings of low-frequency whale calls and ship noise offshore Central Oregon

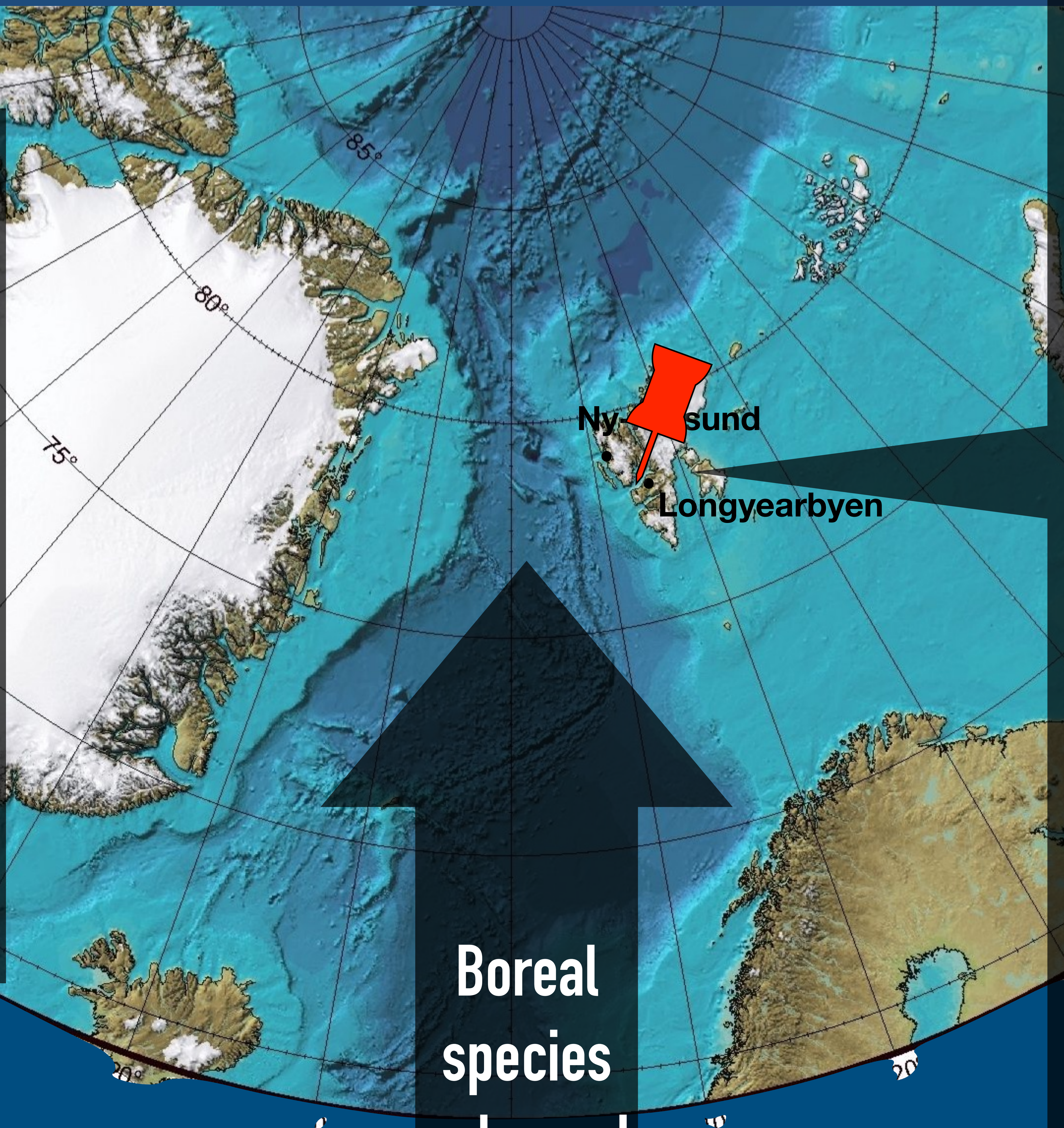
JASA Express Letters 3, 026002 (2023); https://doi.org/10.1121/10.0017104

William S. D. Wilcock[1,a)], Shima Abadi[1,b)], and Bradley P. Lipovsky[2]

Svalbard DAS experiment

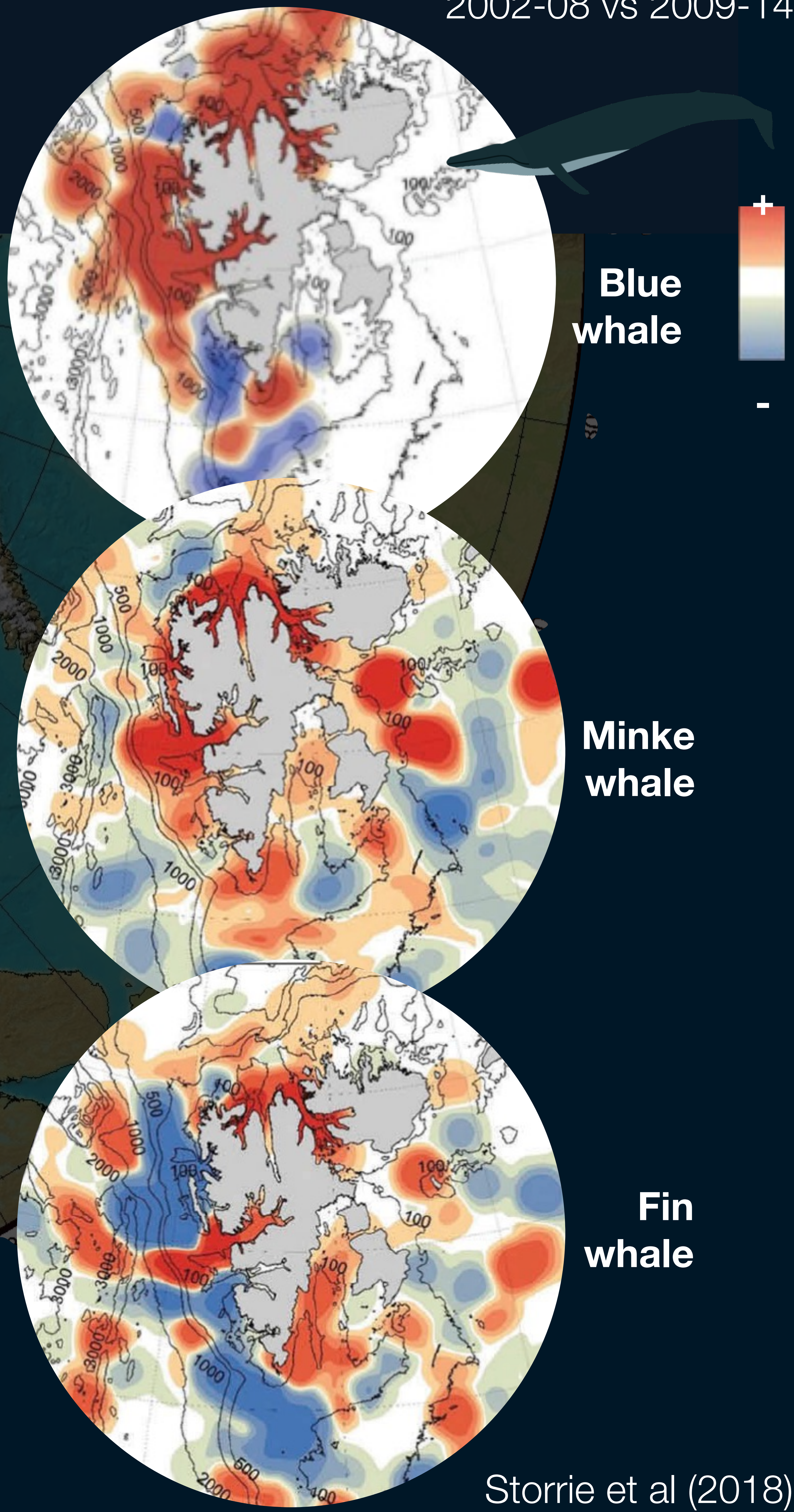


Smith & Stephenson (2013)



Boreal species poleward shift

Change in number of sightings
2002-08 vs 2009-14



Storrie et al (2018)

Svalbard DAS experiment

SFI Centre for Geophysical Forecasting

NTNU

sfi Centre for Research-based Innovation
The Research Council of Norway

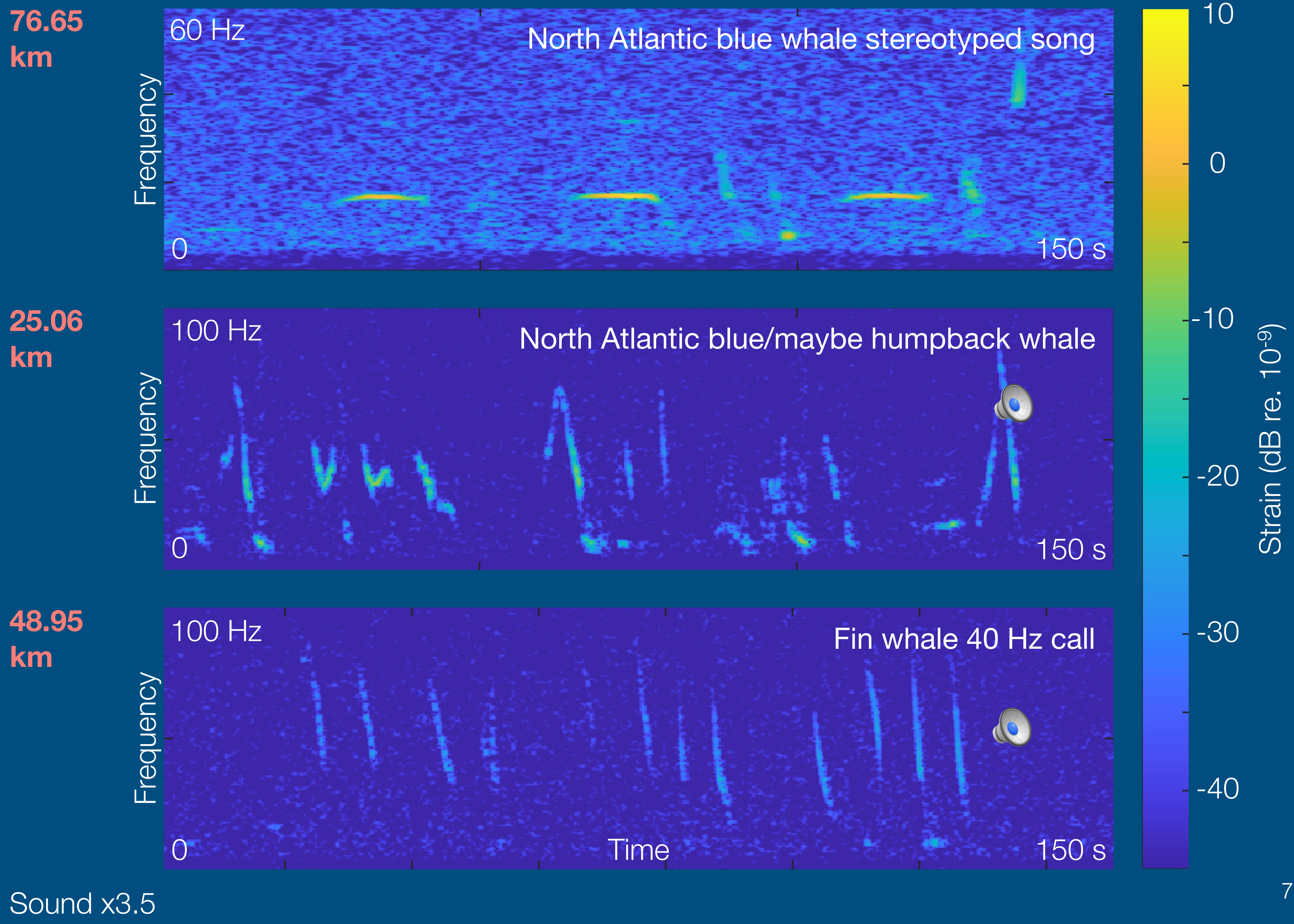
Uninett telecommunication FO cable connecting Longyearbyen to Ny-Ålesund

120 km !

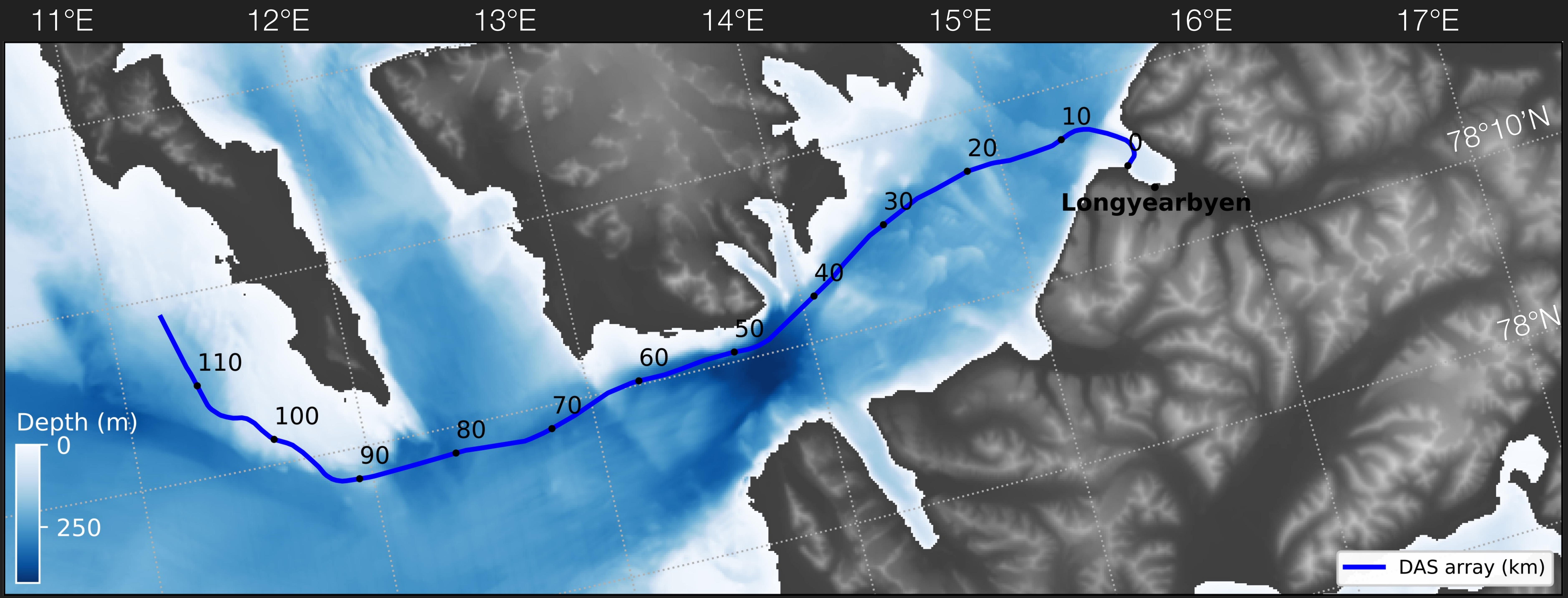
Alcatel OptoDAS interrogator

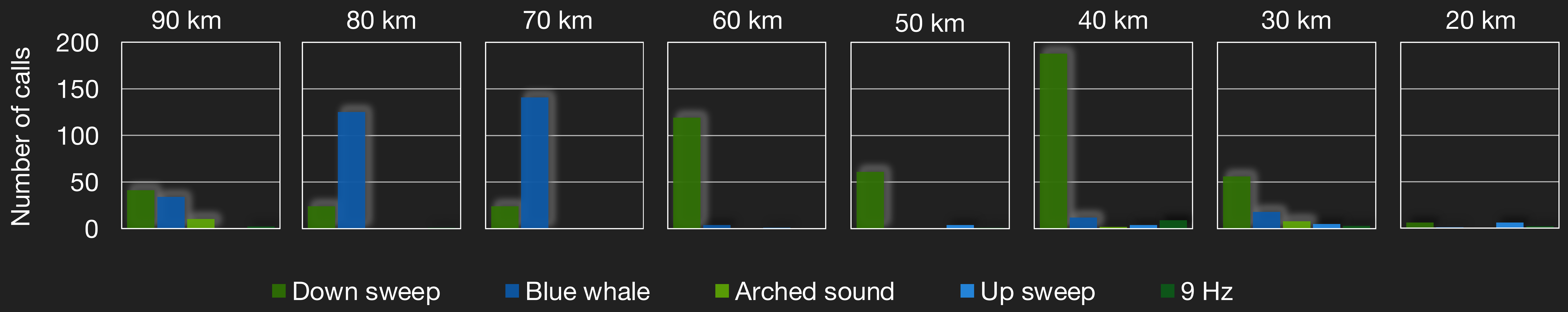
- Summer 2020 (06/23 - 08/05)
- fs = 645.16 Hz
- Spatial resolution: 4m

Vocalization diversity recorded by DAS

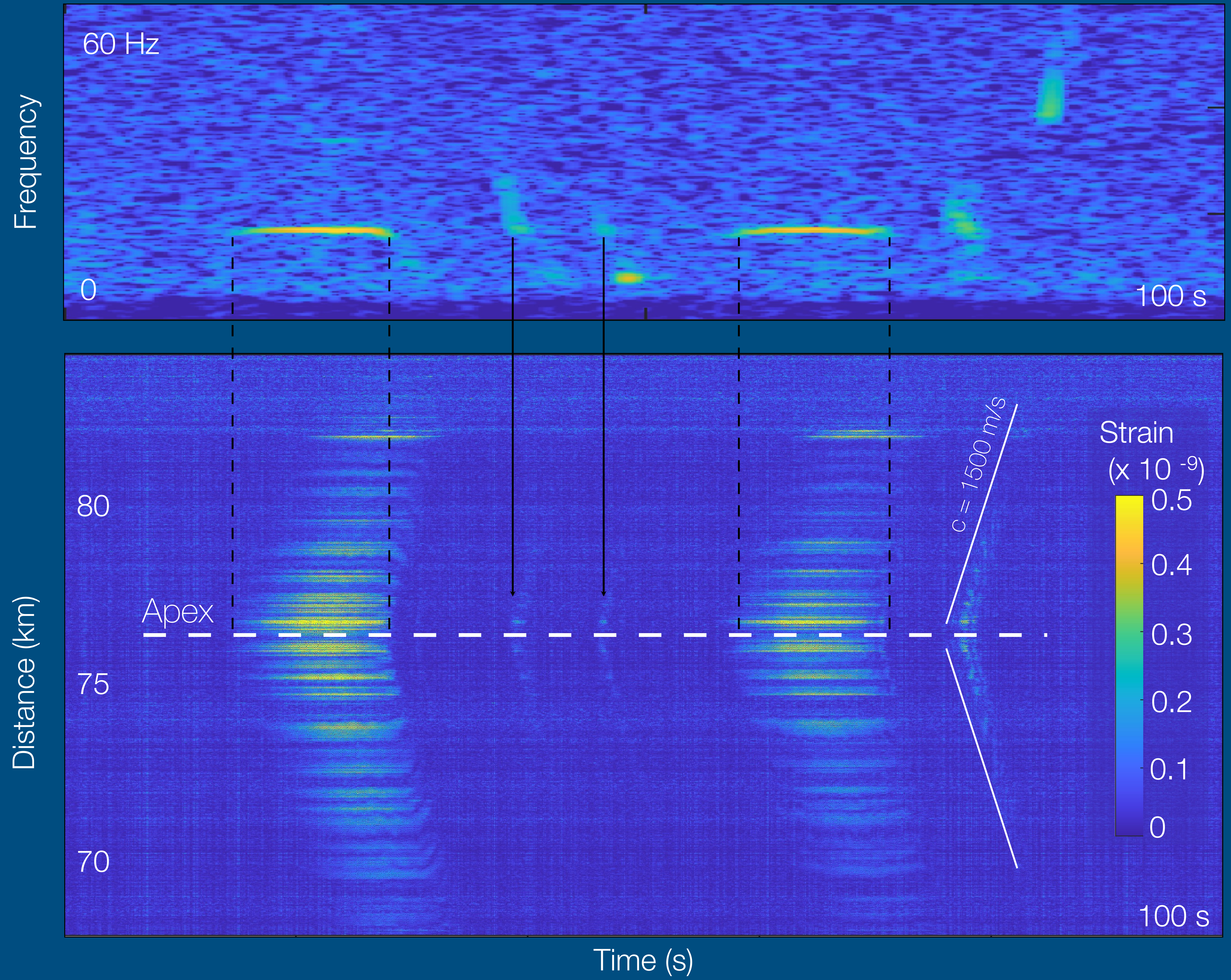


Vocalization diversity recorded by DAS

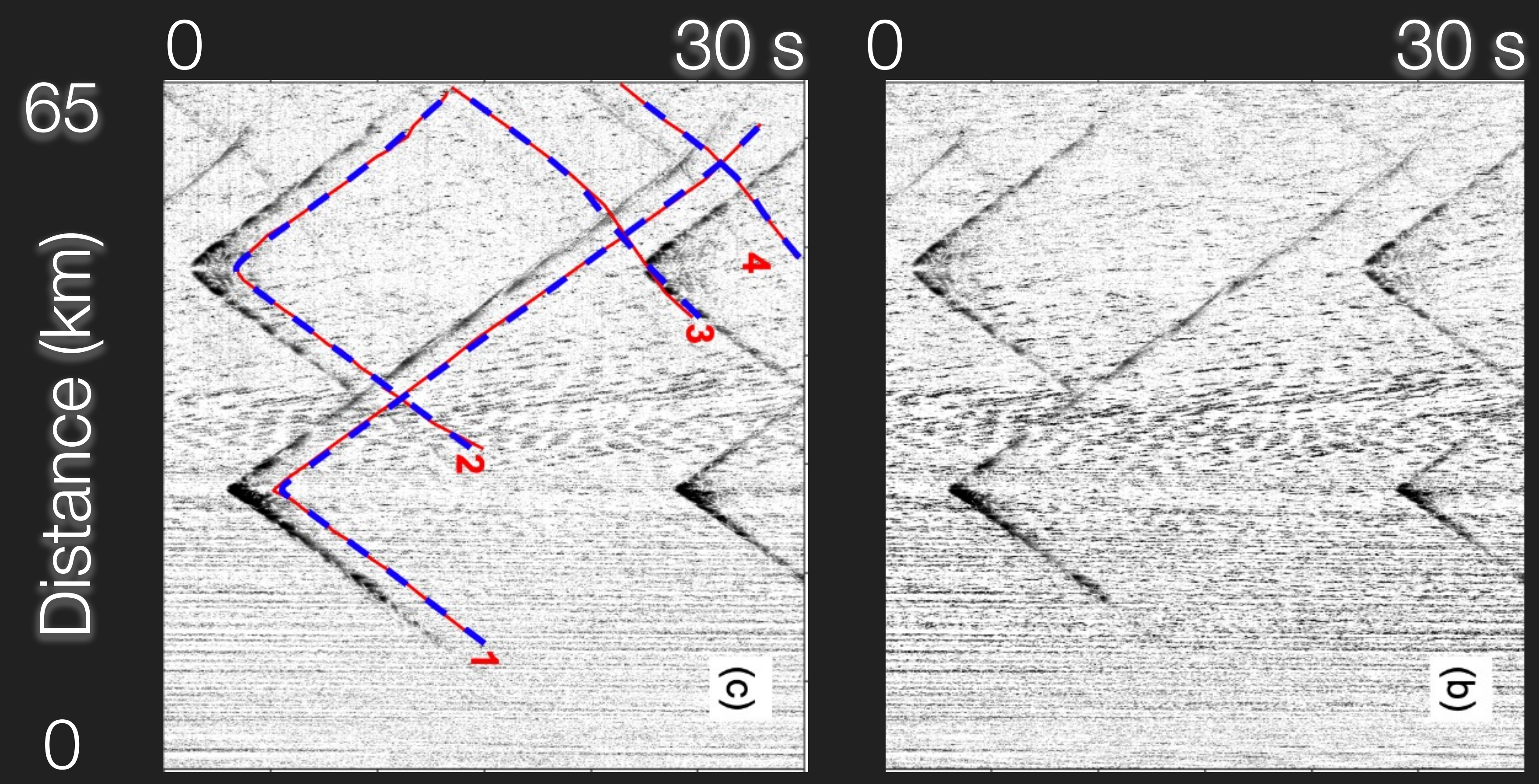




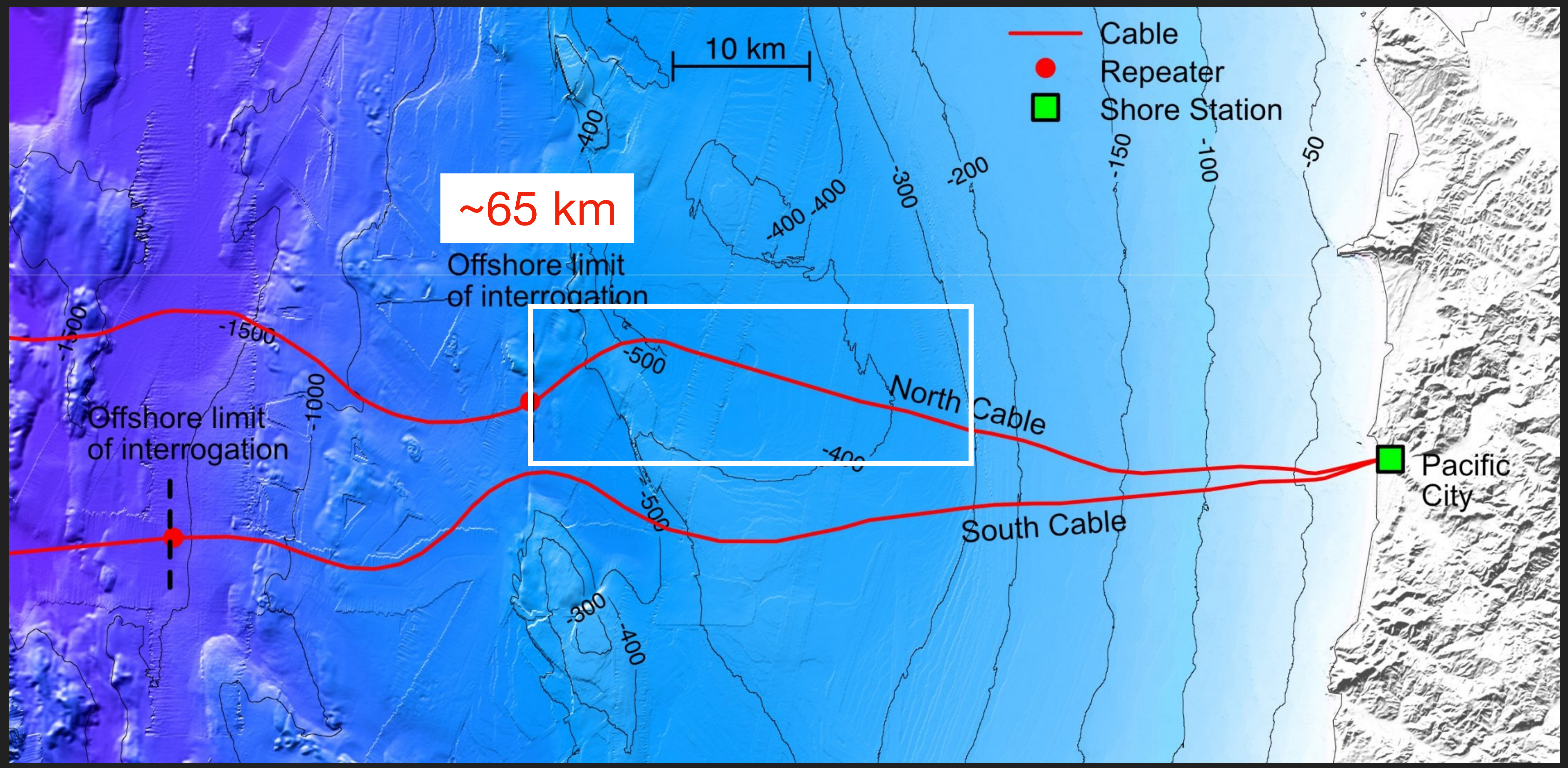
Spatio-temporal representation

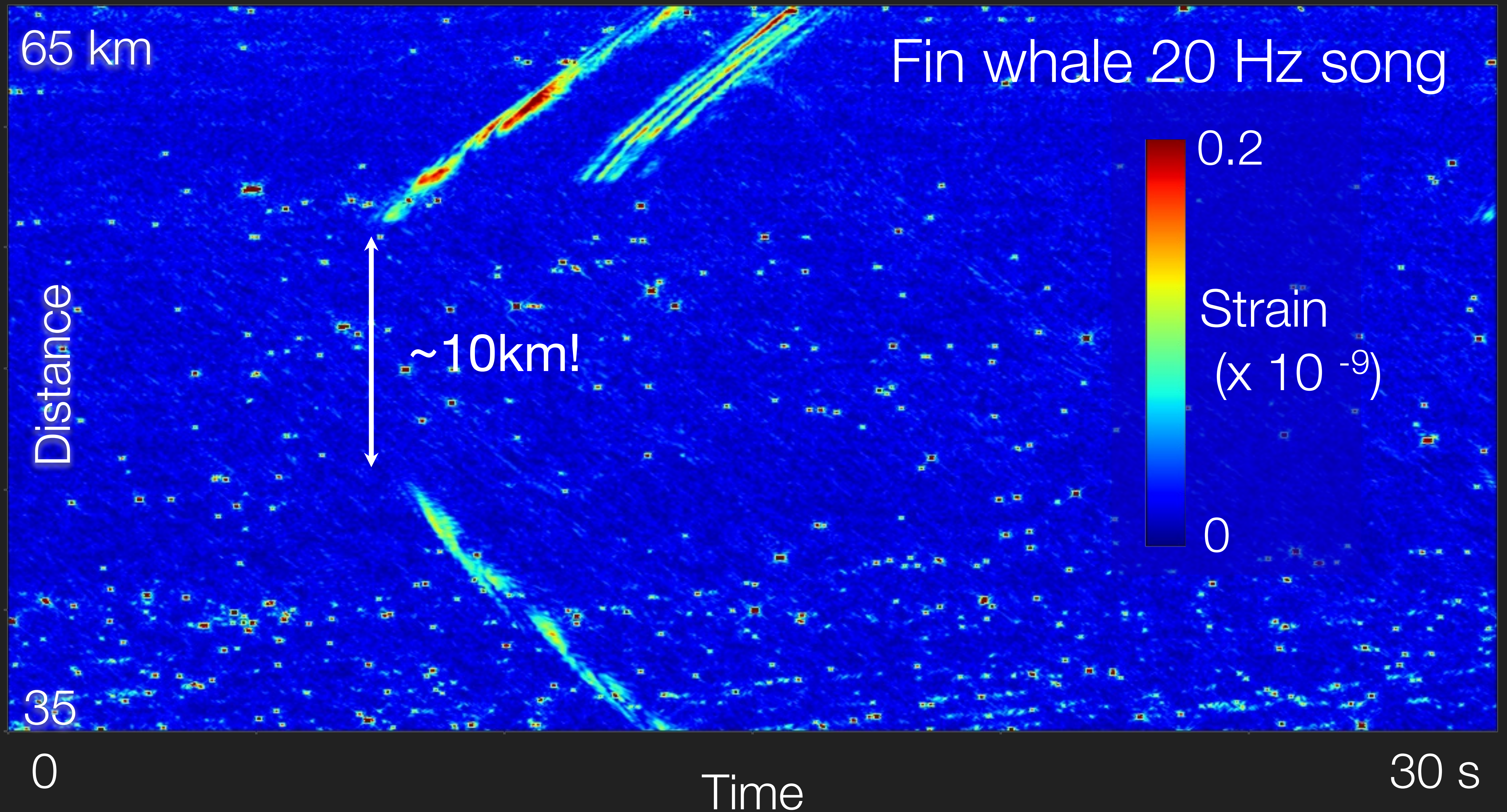


DAS sensitivity and response to whale calls?



Source: Wilcock et al. 2022

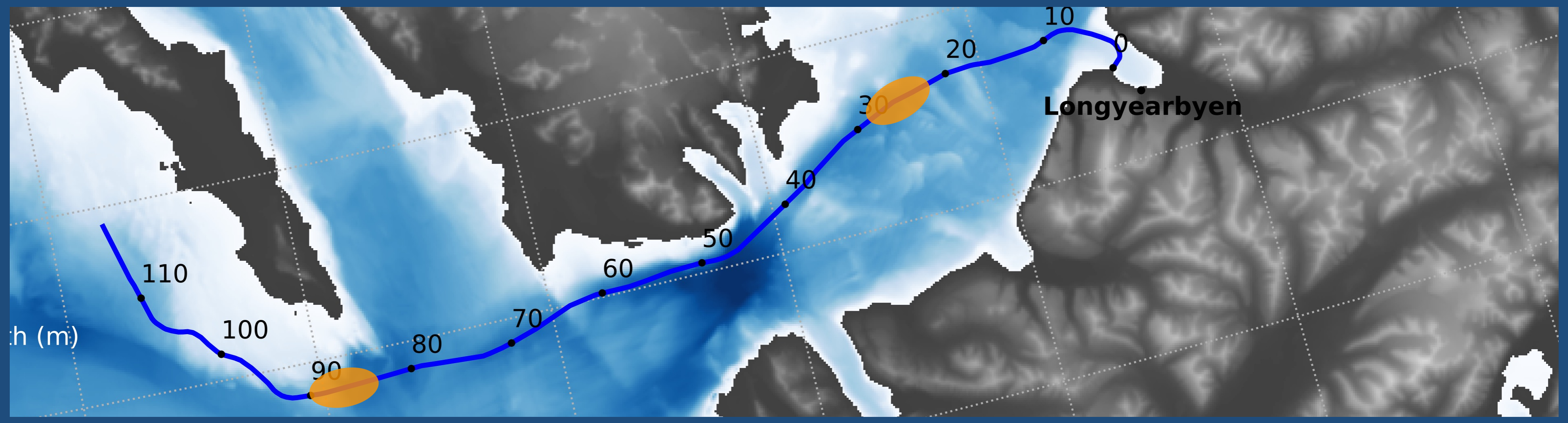


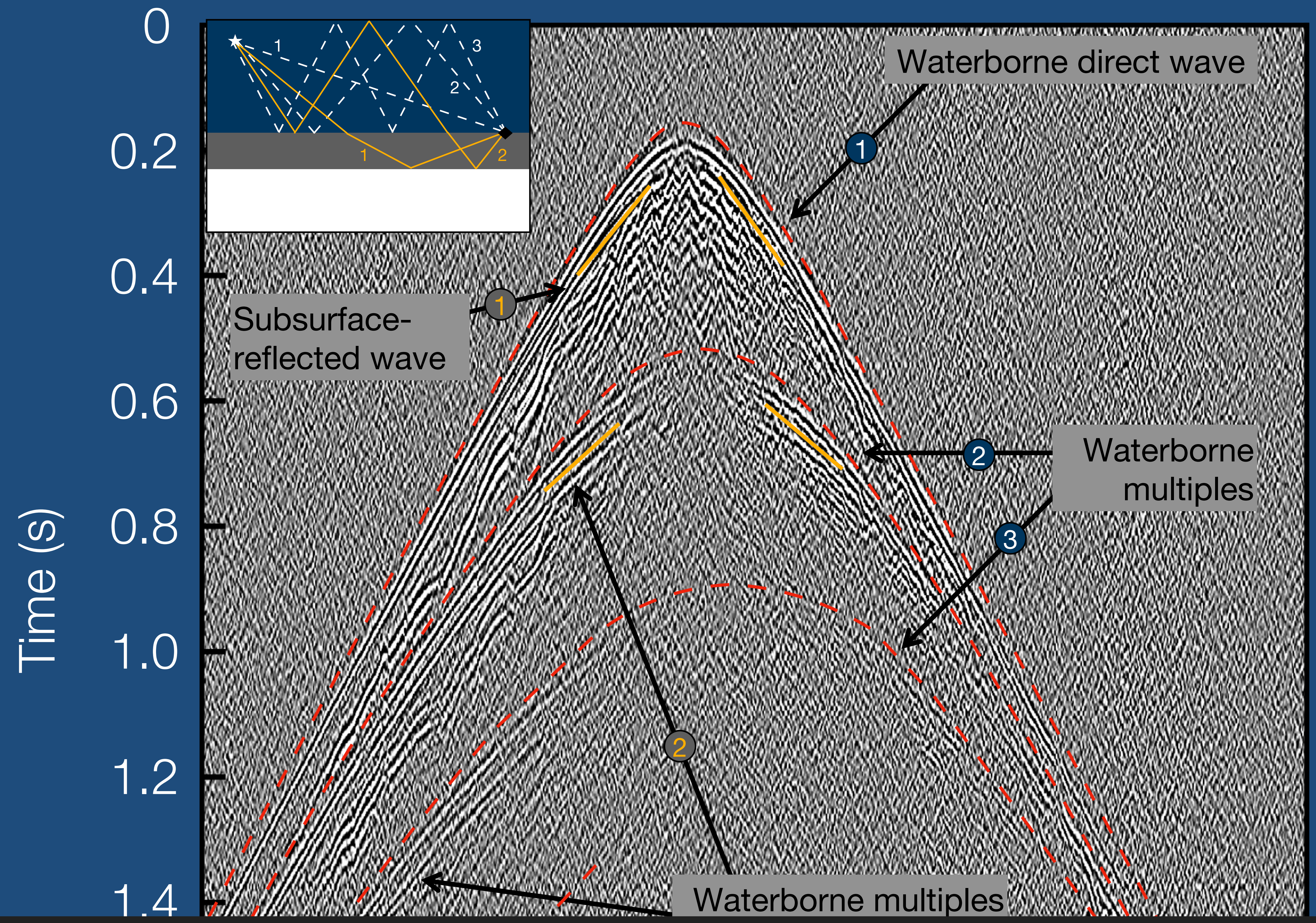


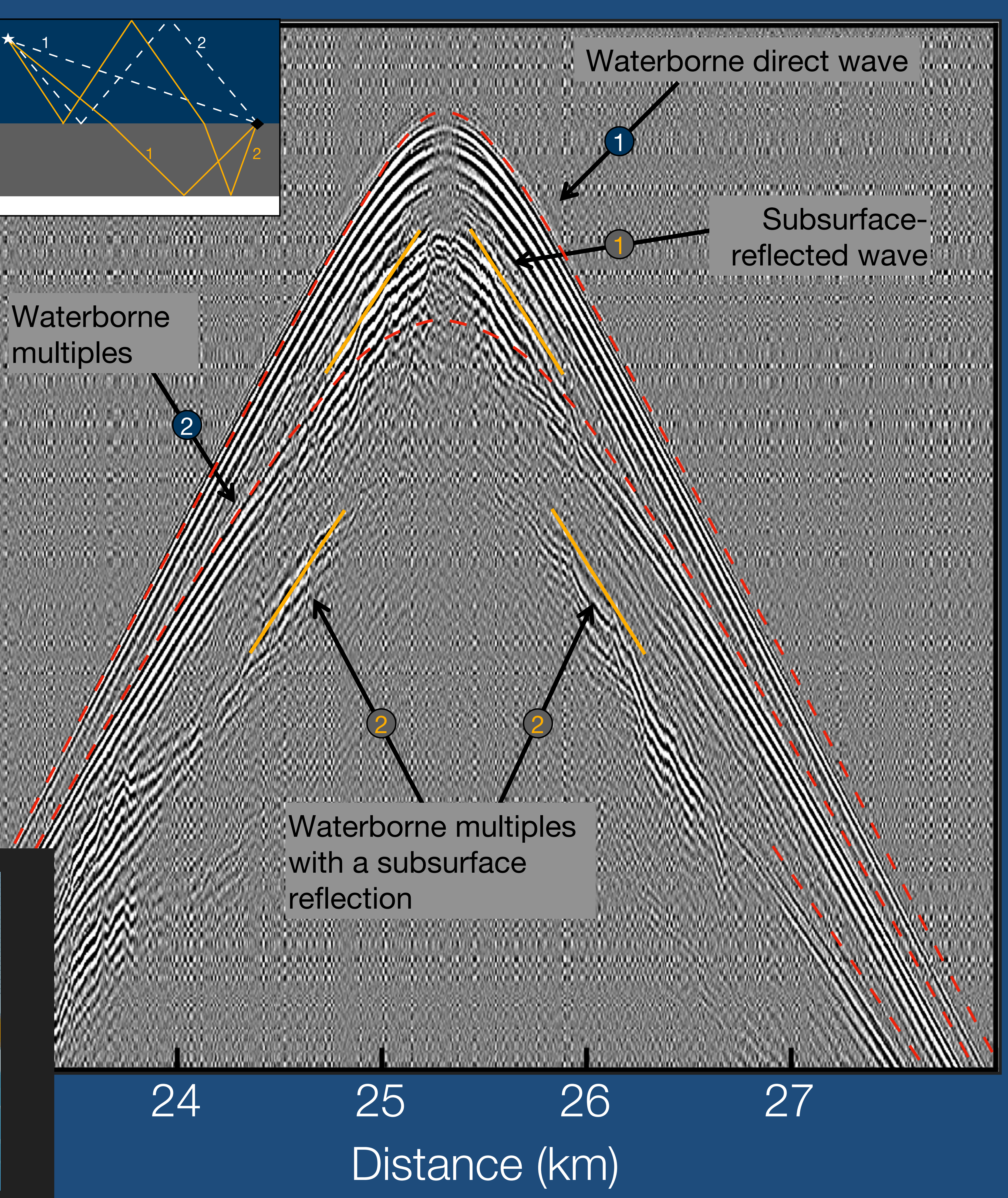
- [data] OOI RAPID: A Community Test of Distributed Acoustic Sensing on the Ocean Observatories Initiative Regional Cabled Array
- [Paper] Wilcock, W. S., Abadi, S., & Lipovsky, B. (2022). Distributed acoustic sensing recordings of low frequency whale calls and ship noises offshore central Oregon. JASA Express Letters, 3(2). DOI: 10.1121/10.0017104

DAS longitudinal strain lacks sensitivity to plane acoustic waves at normal incidence - response depends on the gauge length, the frequency, the grazing angle

Subsurface imaging using D-calls







- [Paper] **Bouffaut et al.** (2022) “Eavesdropping at the speed of light: distributed acoustic sensing of baleen whales in the Arctic,” Front. Mar. Sci. DOI: 10.3389/fmars.2022.901348
- [Data] L. Bouffaut, & K. Taweesintananon. (2022). DAS4Whale: Svalbard distributed acoustic sensing dataset for baleen whale monitoring (1.0.0). Zenodo. DOI: 10.5281/zenodo.5823343
- [Podcast] Utah Public Radio — UnDisciplined: Scientists can now eavesdrop on whales (28/08/22)

Fin whale tracking with 2 cables

- [Paper] Rørstadbotnen et al. (2023) “Simultaneous Tracking of Multiple Whales using two Fibre-Optic Cables in the Arctic,”Front. Mar. Sci. DOI: 10.3389/fmars.2023.1130898

What are our next moves?

Proof of concept

- Acoustic recordings at a minimum infrastructural & operational cost
- Spatial coverage
- Potential for real time monitoring of crucial areas

1 Assess the quality of DAS-recorded data

- What is the frequency response of DAS?
- What is the sensitivity of DAS?
- How does the response change depending DAS configuration?

2 Implementation for conservation

- How does DAS compare to traditional monitoring methods? (Acoustics and others)

3 Accessibility

- We have the opportunity to start something from scratch
- Develop the methods to process the data

DAS for Biology, Conservation & Ecology of whales and their habitats

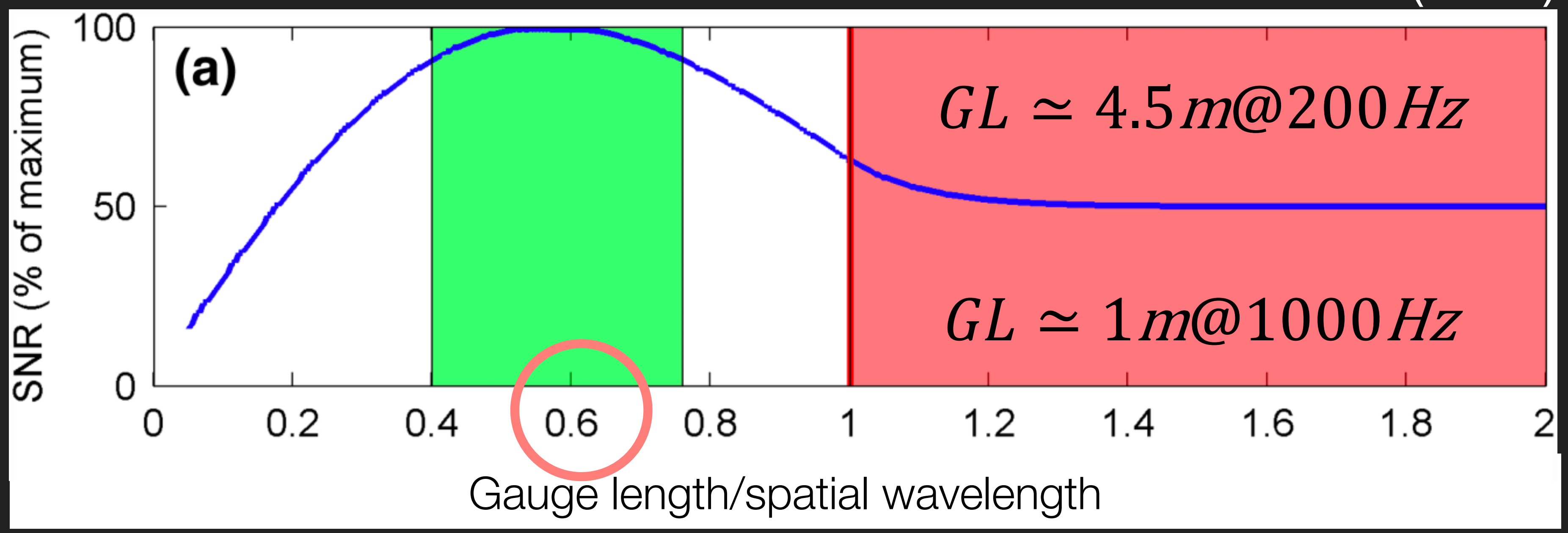
1 Assess the quality of DAS-recorded data

Current limitation in coverage: the first repeater at ~ 50 km

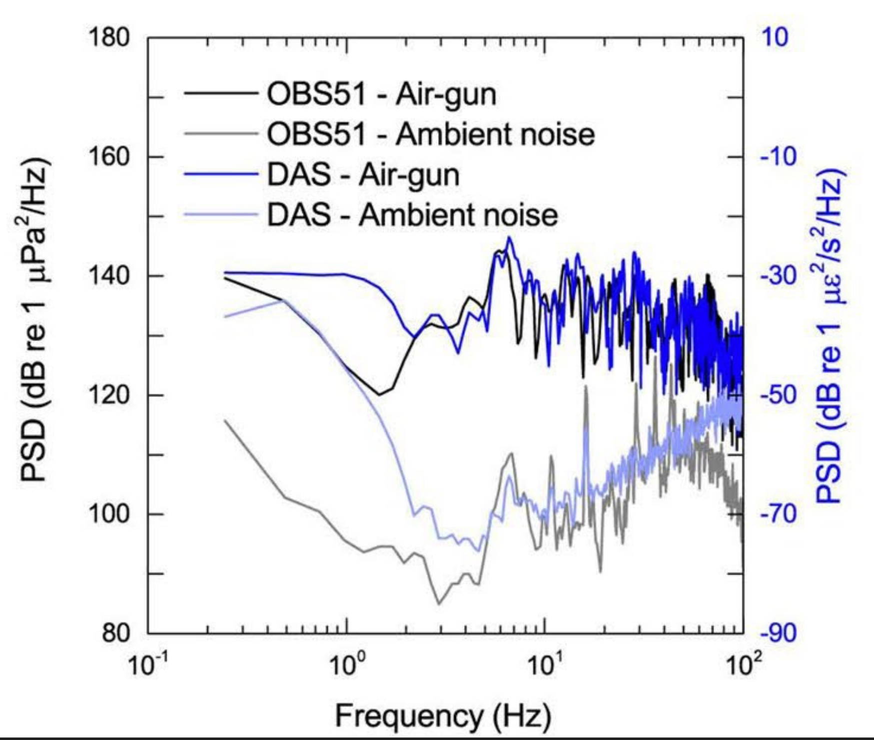
fs (kHz)	Max fiber length (km)
1	97
2	48
4	24.5
10	9.7
22	4
96	1

- Gauge length optimization for higher frequency signals

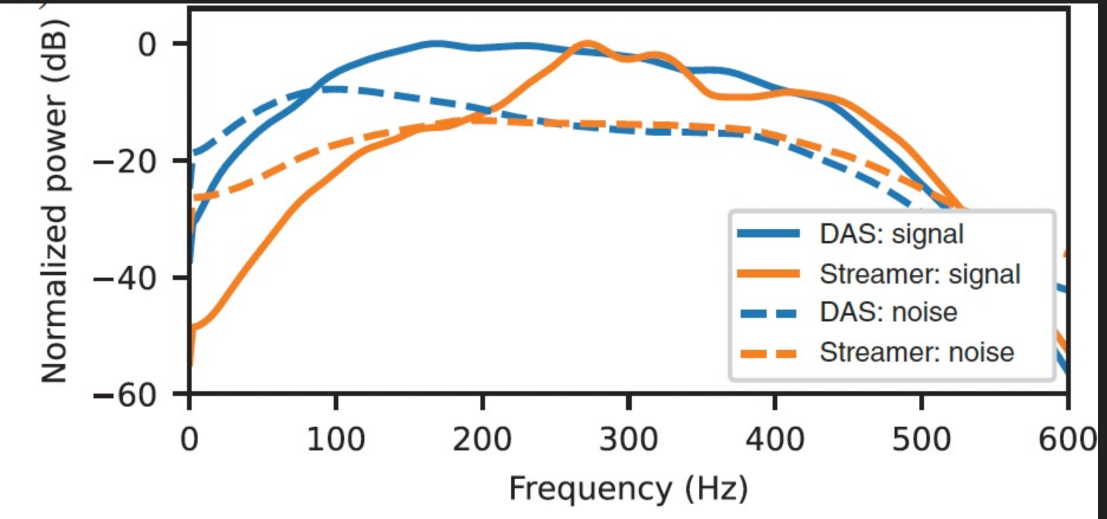
Source: Dean et al (2016)



- Extend the known frequency response & sensitivity

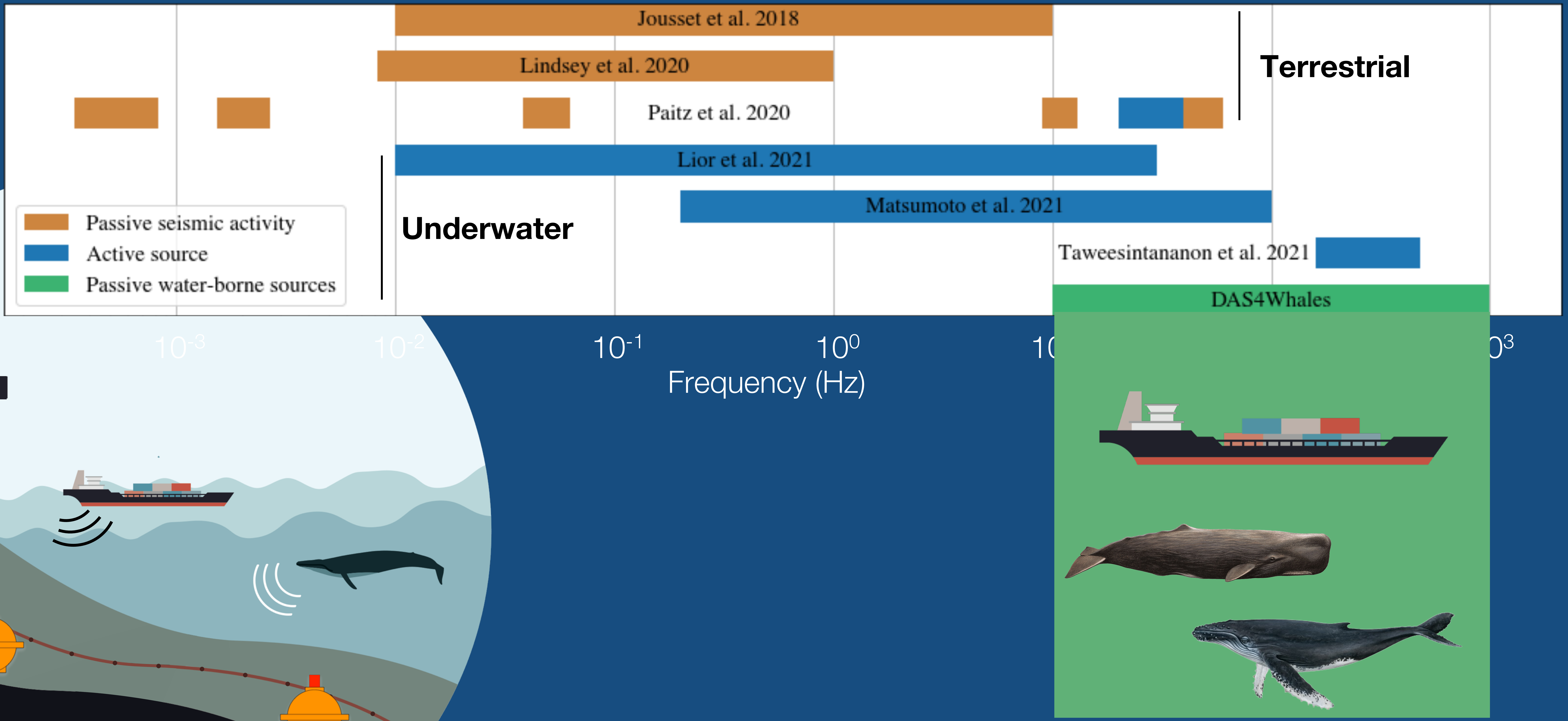


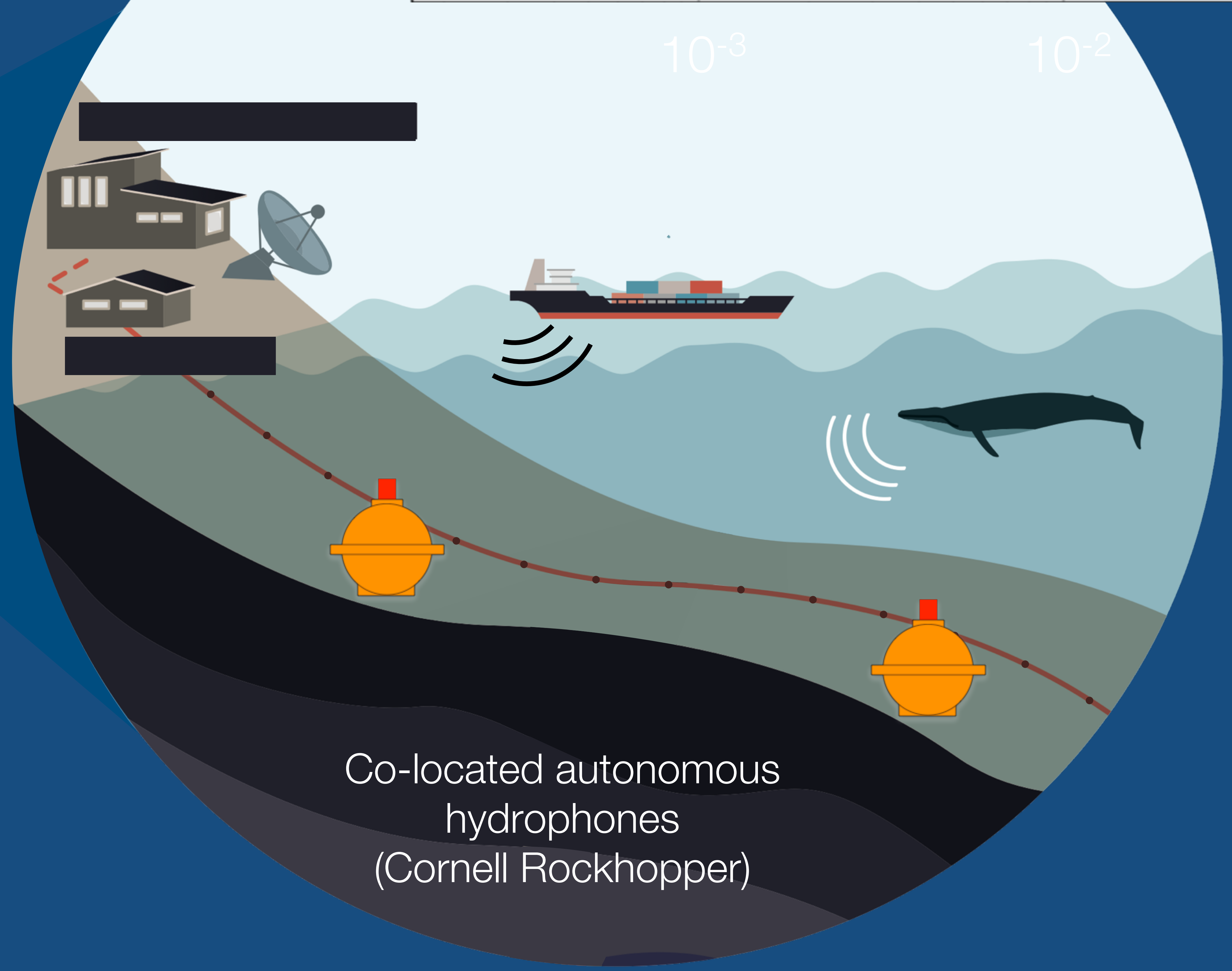
Source: Matsumoto et al. (2021)



Source: Taweesintananon et al. (2021)

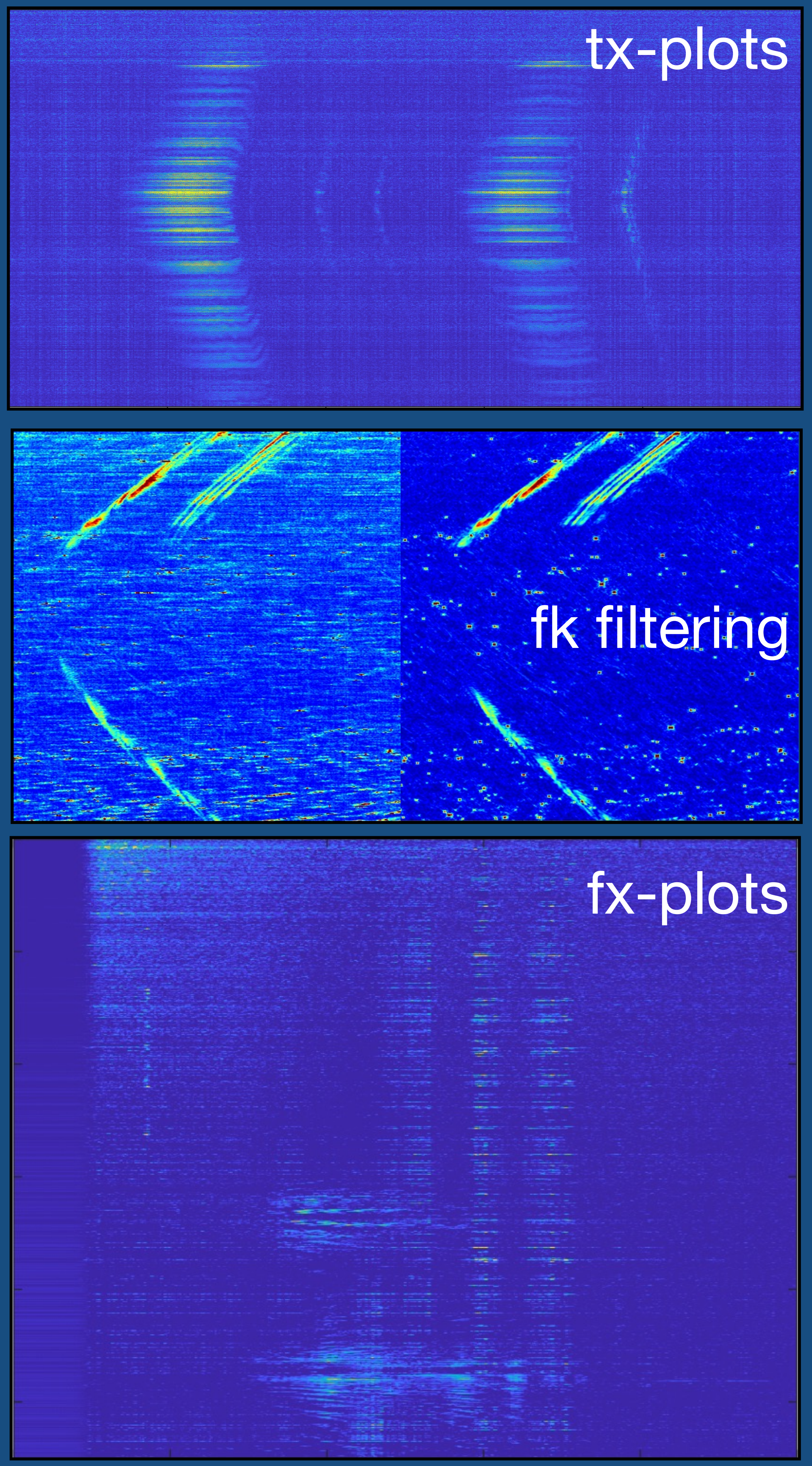
1 Assess the quality of DAS-recorded data



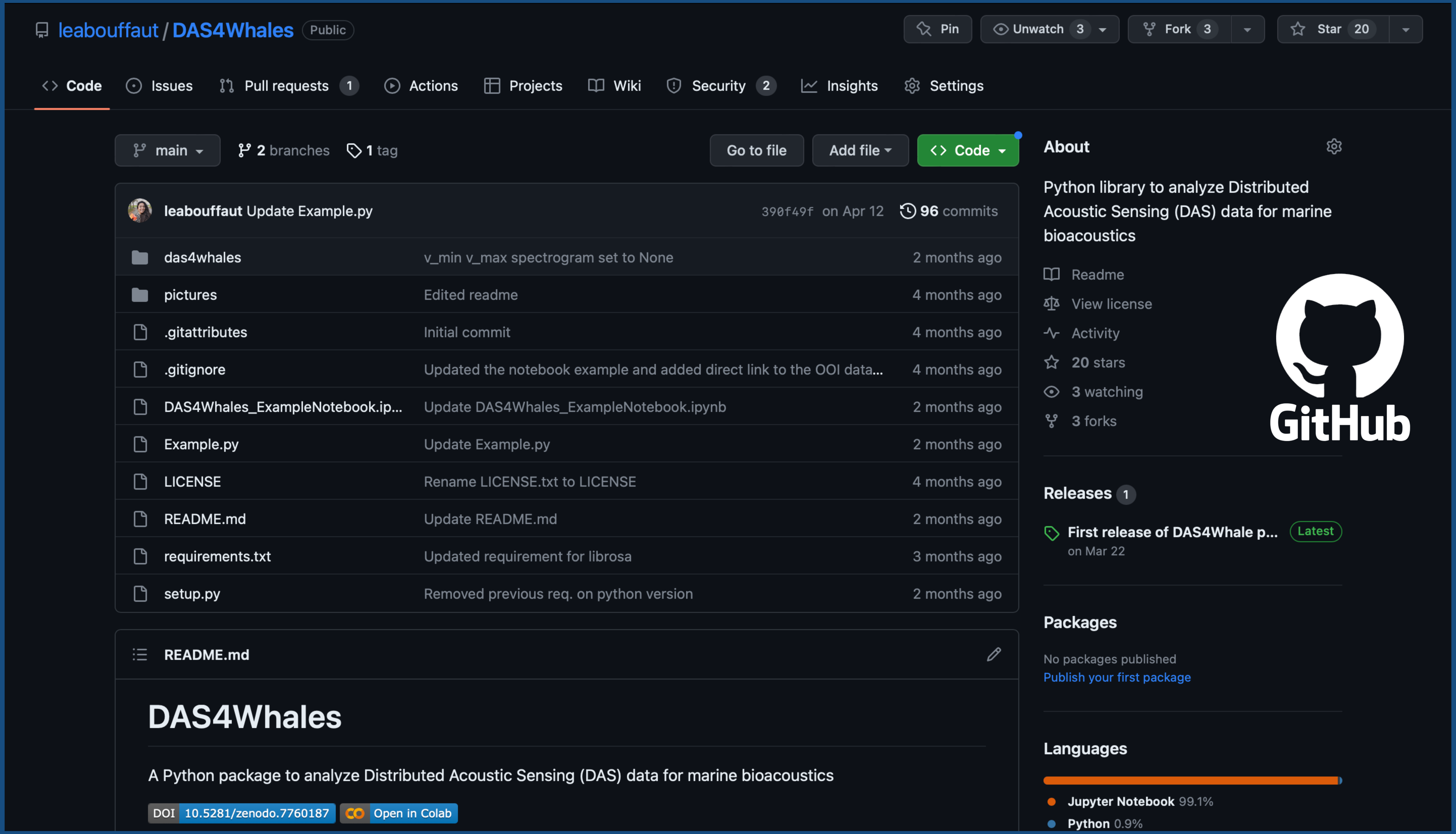


3 Accessibility

DAS4whale: a python package to analyse DAS data for bioacoustics



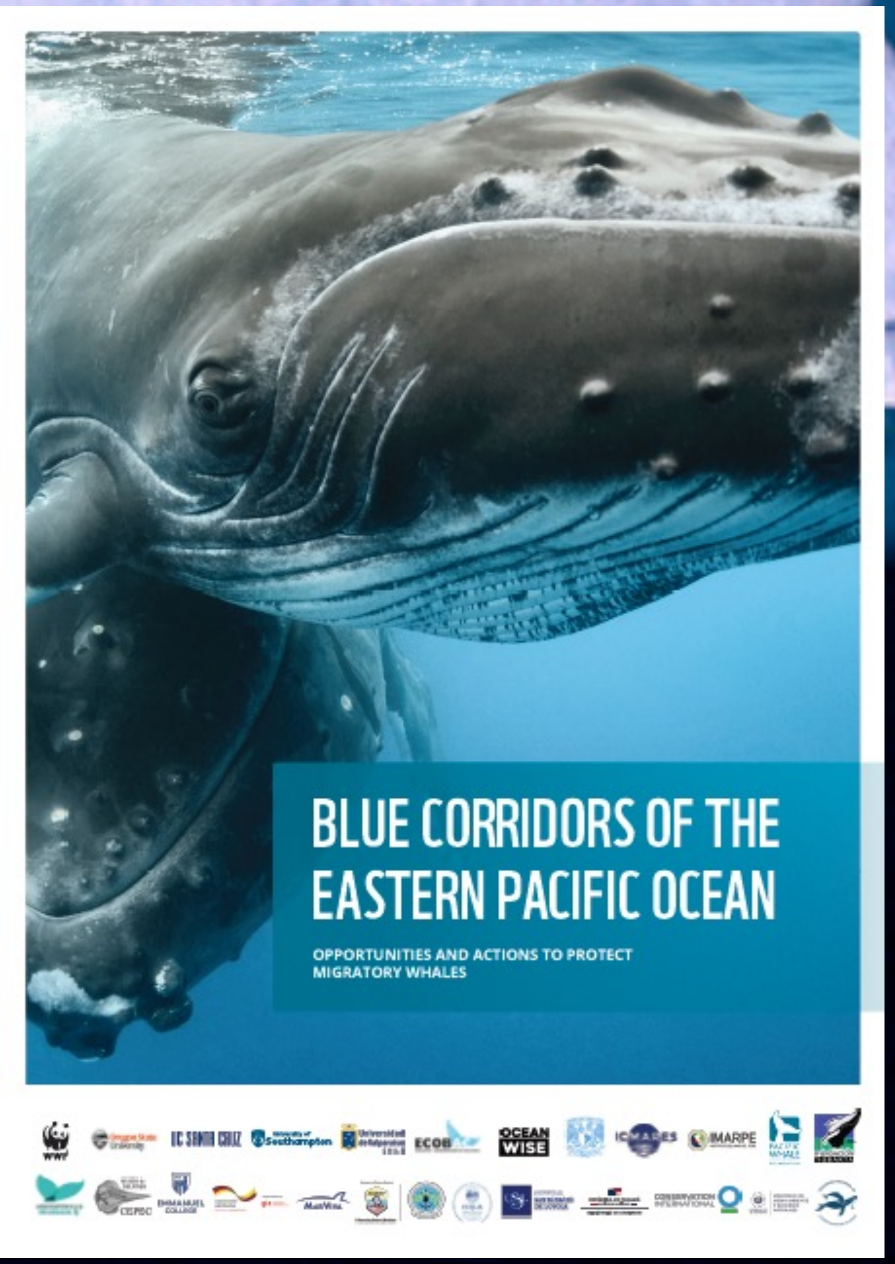
Export audio



Colab notebook, no python installation required!

Conservation applications

- WWF is working to **protect blue corridors** – whale migration routes around the planet.
- Maintaining migratory connectivity is essential for animals that move between seasonal habitats. It also promotes healthy, connected oceans for nature and people.
- WWF is currently advocating for conservation of these essential habitats globally and regionally in the Eastern Pacific, Atlantic and Arctic Oceans.



To safeguard whales on their migrations, we need tools to monitor and manage blue corridors that are dynamic, accessible and cover large geographic scales.

https://wwfwhales.org/resources/protecting-blue-corridors-report
https://www.arcticwwf.org/our-priorities/nature/arctic-blue-corridors/

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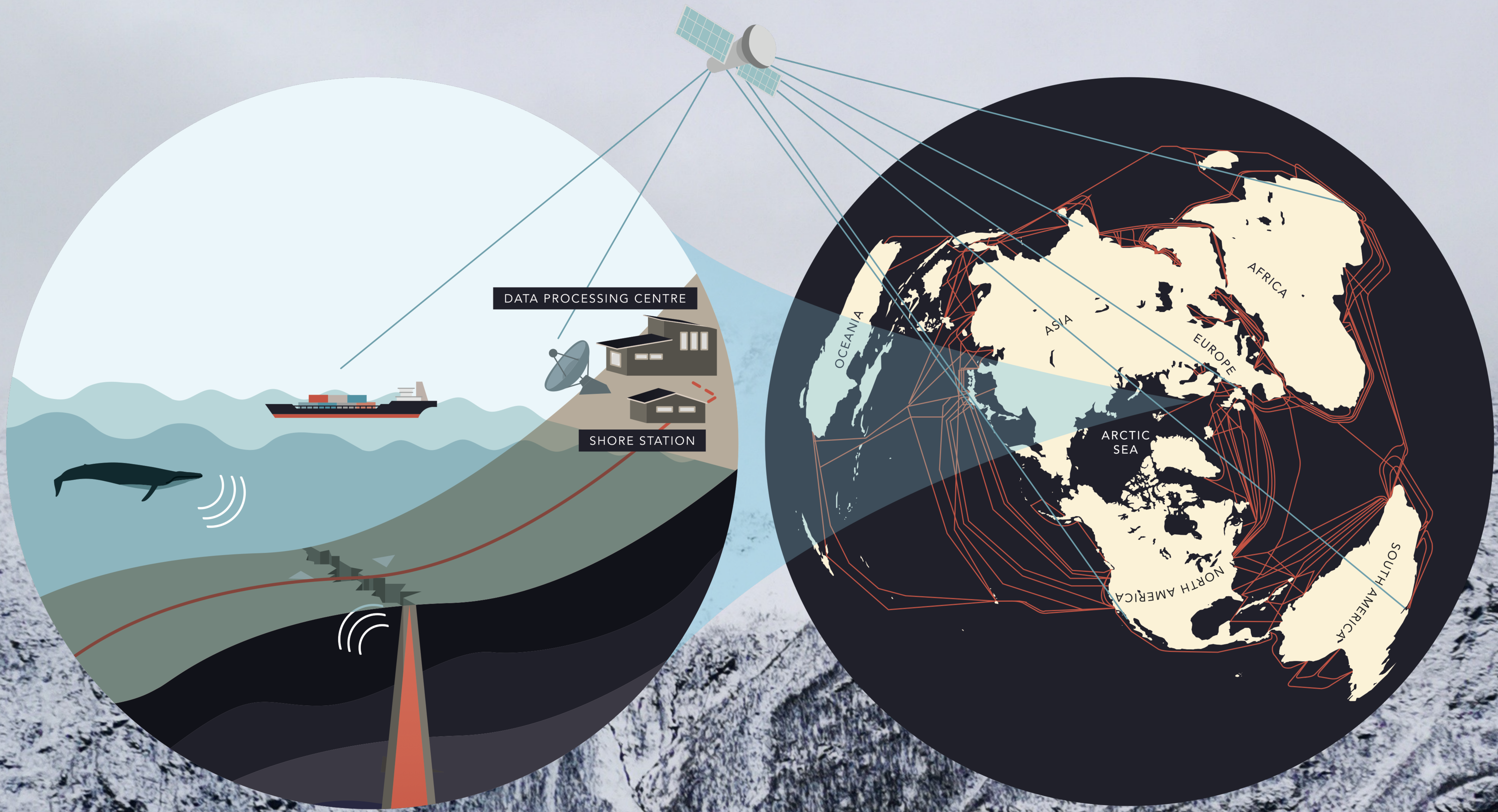
WWF



Thank you!

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