# Sound for survival, pleasure, and exploitation.

Hanne Sagen and Espen Storheim

Resources for further informaiton:

International Quite Ocean Experiment – https://iqoe.org

Discovery of Sound in the ocean - https://dosits.org

# Sound is important for us

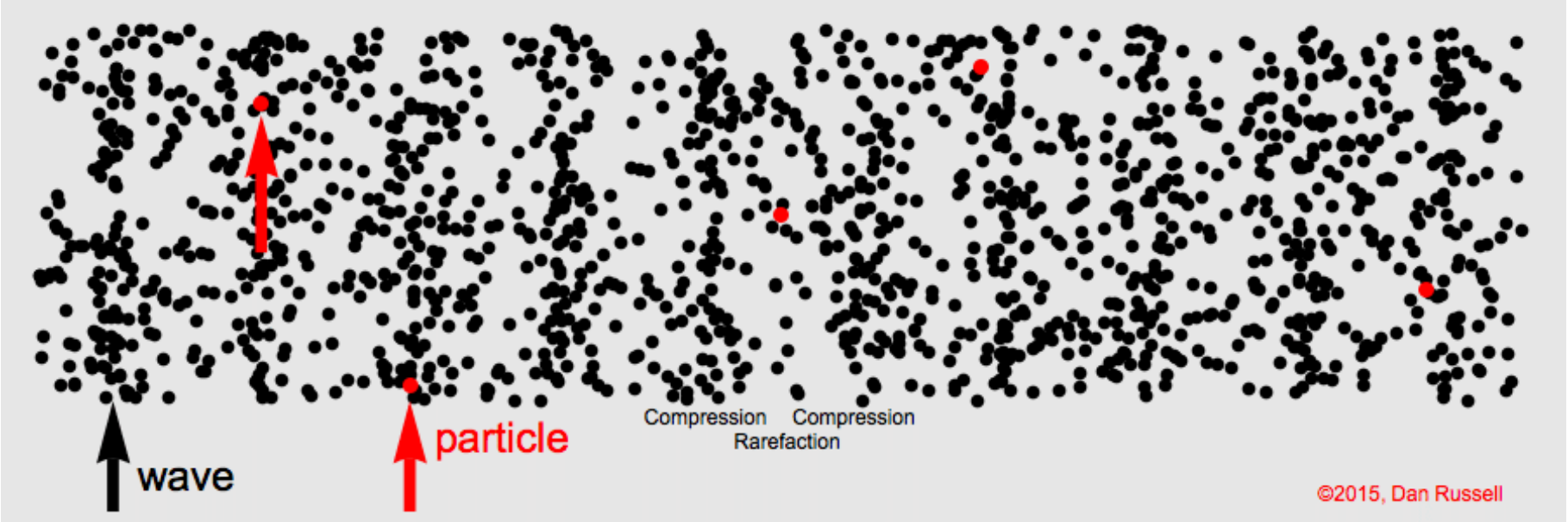
- Music can express and induce feelings
- Spoken language is used to communicate
- Warning – protect our self from danger
- Extract information from background sound

Noise can make it difficult for us!

# Advanced use of sound

- Medicine (e.g. Ultrasound)
- Search and Rescue (e.g. black-box)
- Oil and gas (e.g. seismics)
- Fisheries (e.g. echosounders)
- Military (e.g. location of submarines)
- Mapping of seafloor (e.g echosounders)
- Research (e.g. echosounders, tomography)

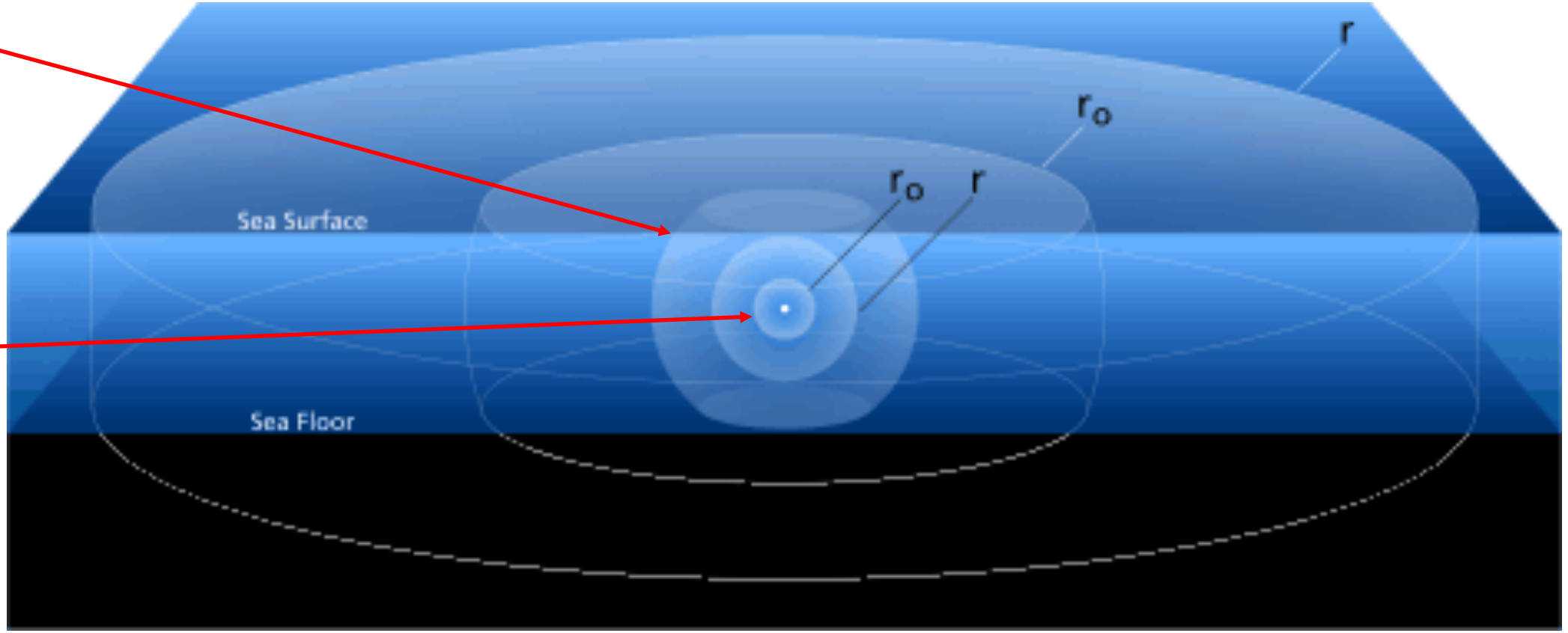
# What is sound?




- Pressure waves propagate in all media.
- C= 340 m/s in air, 1500 m/s in water, 3000m/s in solid

# Sound in the ocean: Spherical and cylindrical spreading

- 1/R
- $1/R^2$

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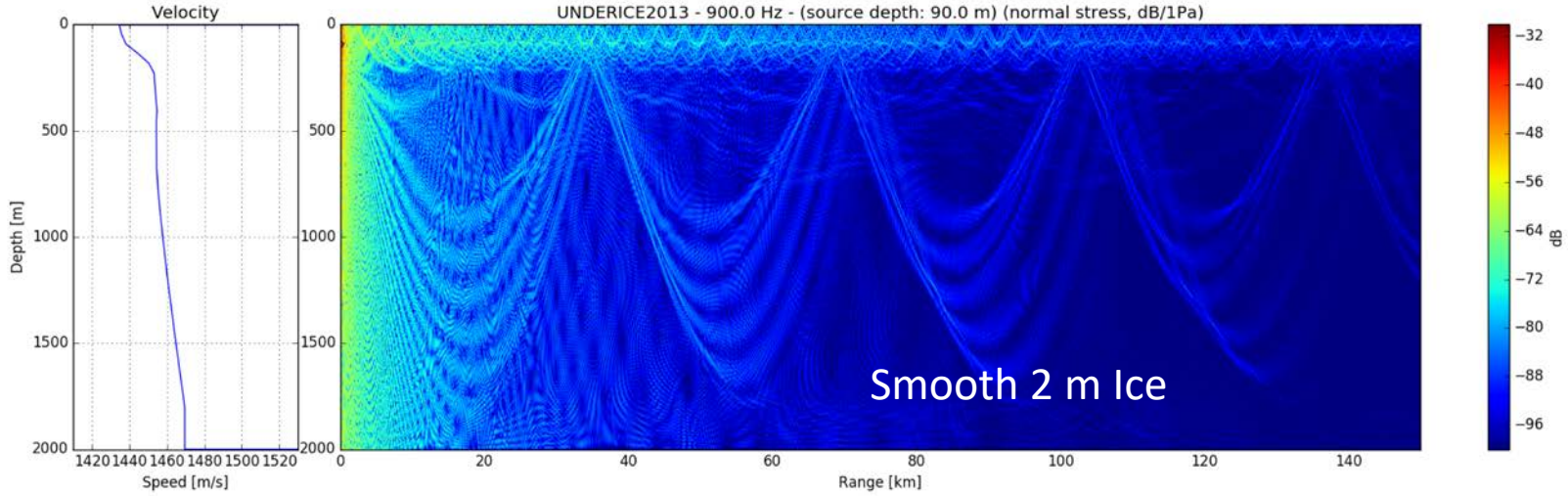
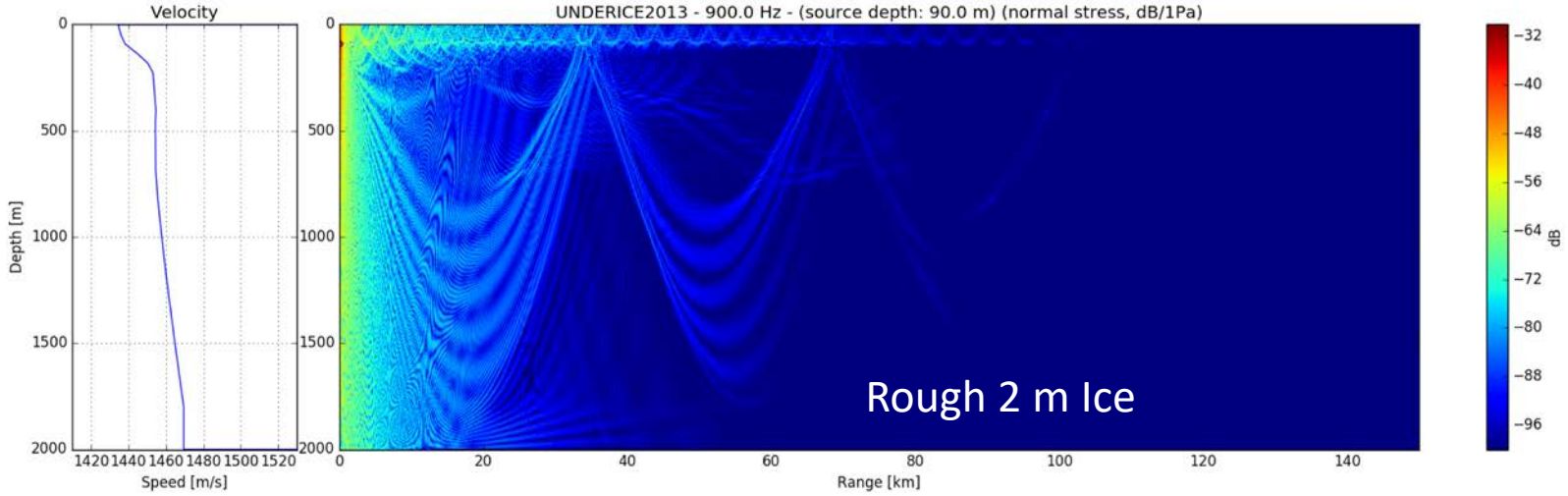
# Acoustic propagation in an Arctic environment (900 Hz)




Changes in the ice conditions influence the acoustic Propagation.

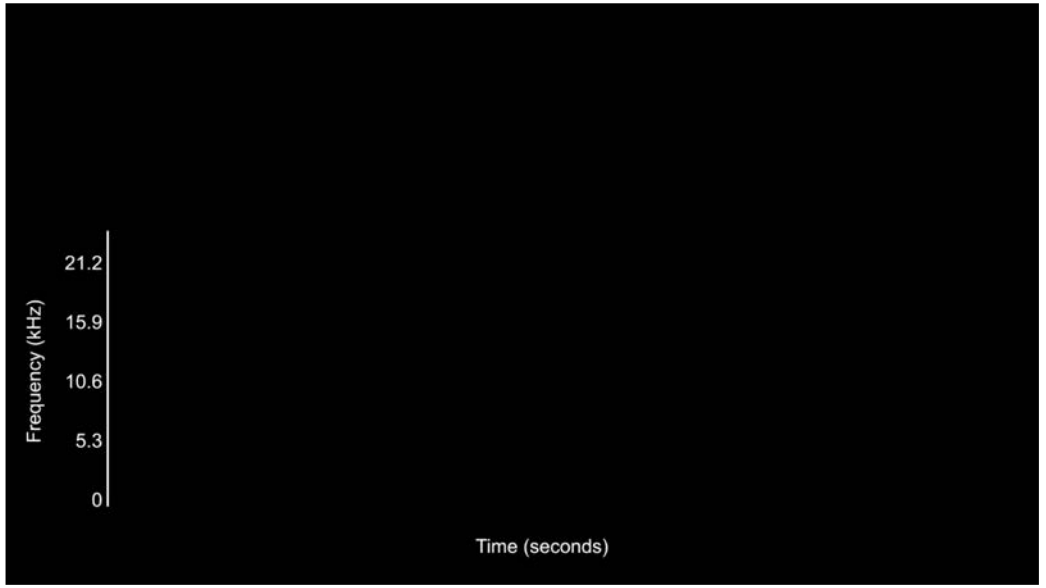
OASES modelling
Gaute Hope, 2017

# Marine animals and sound

- Marine animals rely on sound to communicate, protect themselves, locate food, navigate underwater, and understand their surroundings.
- Sound is crucial for survival and maintenance of group structure
- Marine animals are able to produce and receive complex sounds to communicate different messages quickly and over long distances in the ocean.
- Different species have their own characteristic sounds
- Ocean sound is an Essential Ocean Variable
- Noise pollution in the ocean  is an indicator for  good environmental status in the ocean (Eu's Marine Strategy Framework Directive)

# Killer whale - Hunting high and low….

Killer whales can frighten other marine mammals 100 km away. They operate in well organised hunting teams.

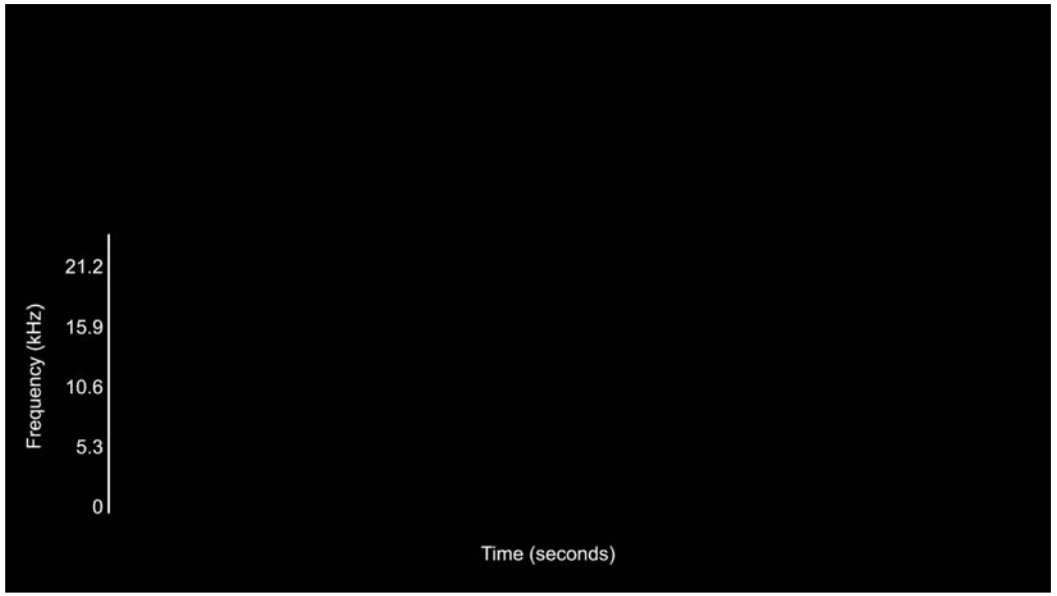



https://www.livescience.com/27431-orcas-killer-whales.html

https://dosits.org

# Narwhals

Only found in the Arctic. The tusks may be able to detect water temperature, pressure and salinity (Not everyone has its own CTD!!!).

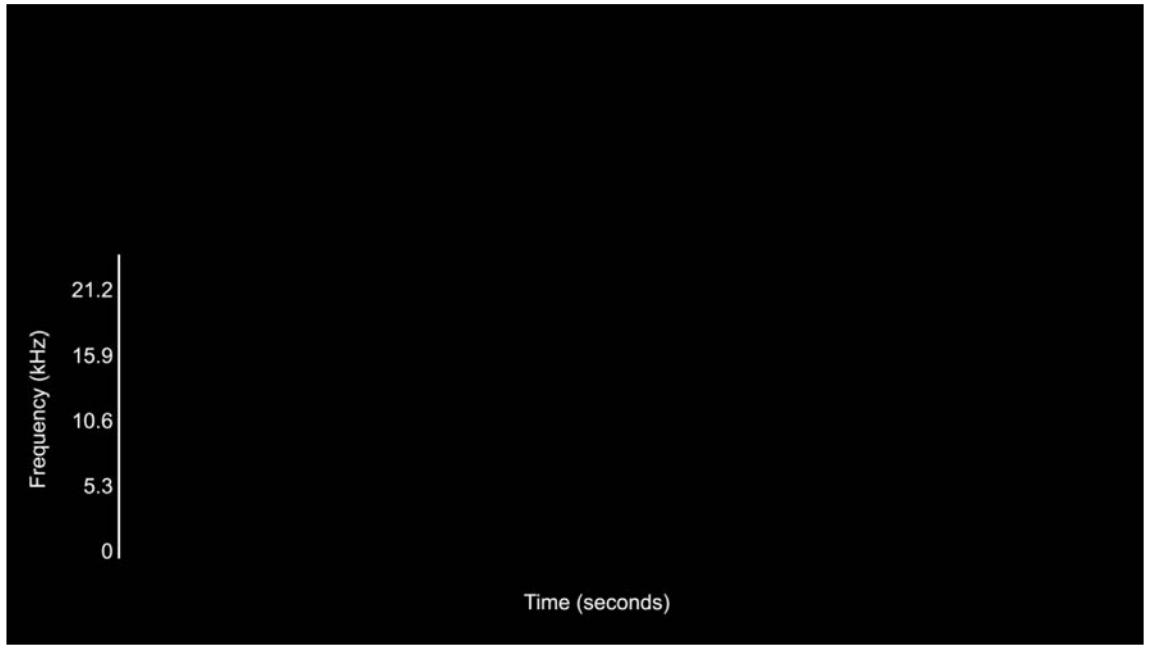



http://minnesota.publicradio.org/events/2013/11/a-beautiful-world/images/Narwhal3.jpg

https://dosits.org

# Bearded seal (storkobbe) – prince charming

Adult bearded seal by by wildlife photographer Paul Souders

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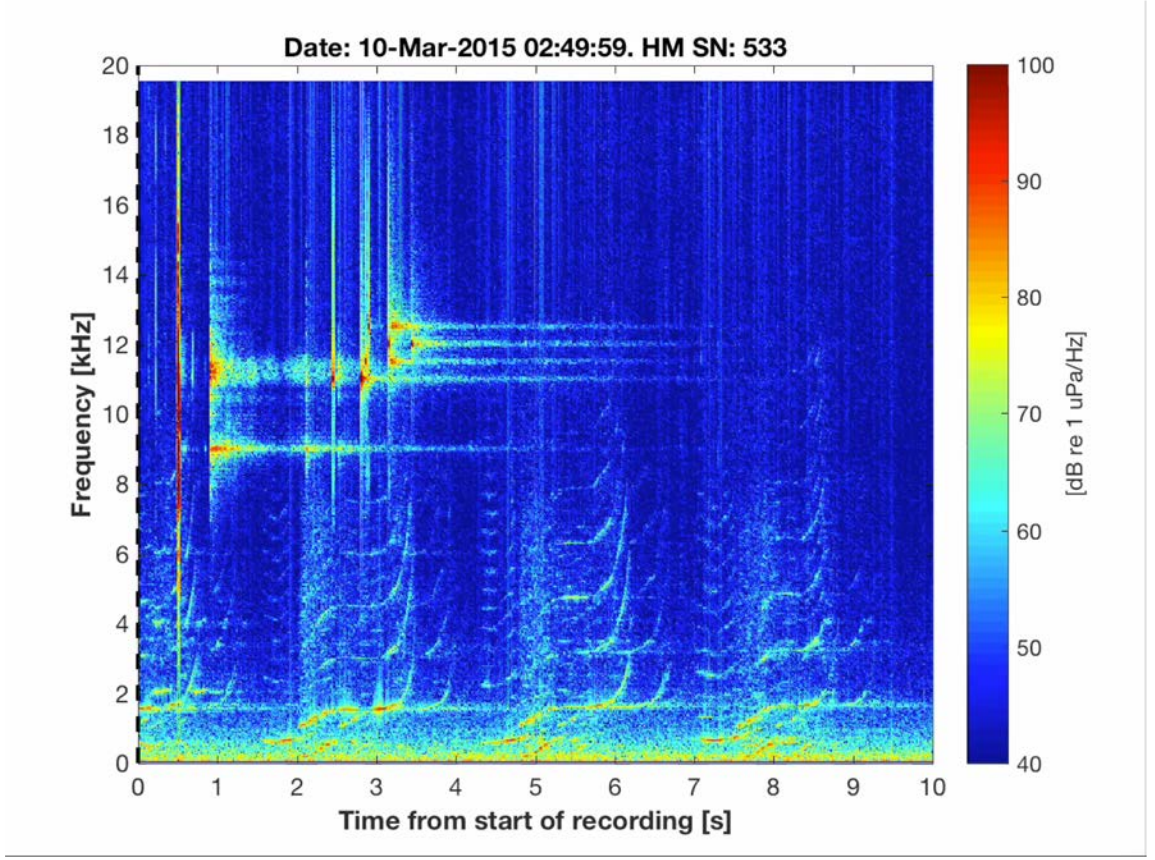
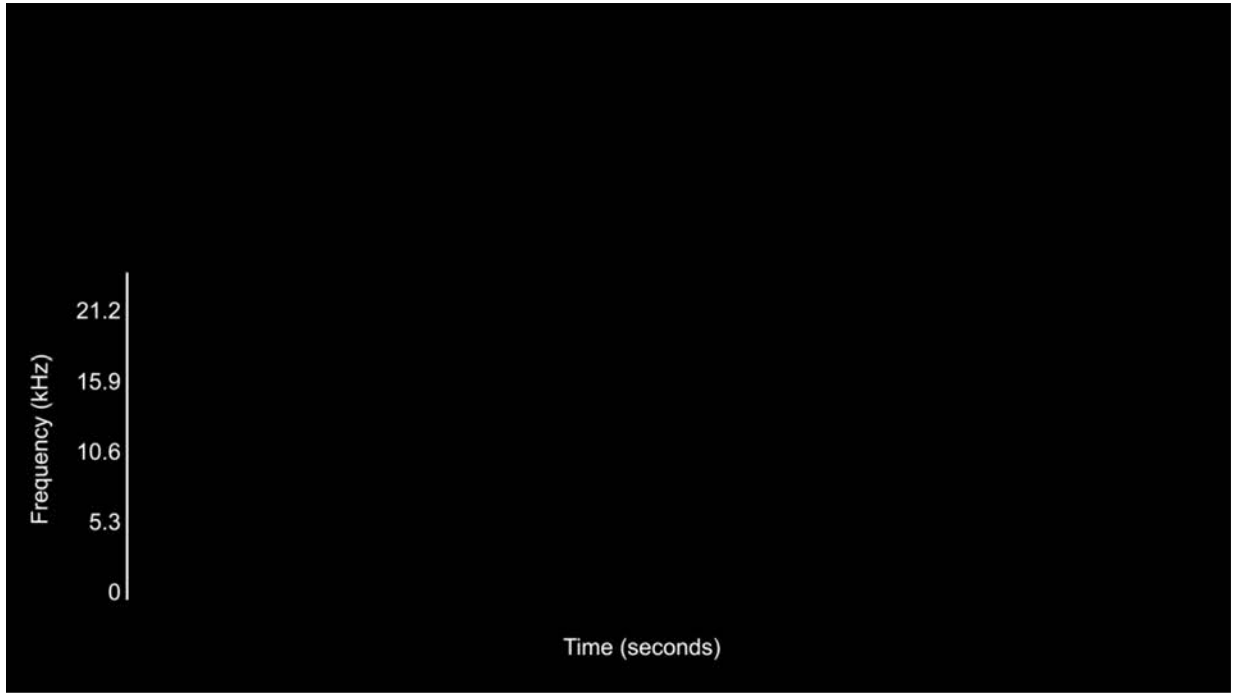
# Bowhead whale

Bowhead whales are considered to be the longest living mammals, living for over 200 years. They can break through 60 cm of ice!

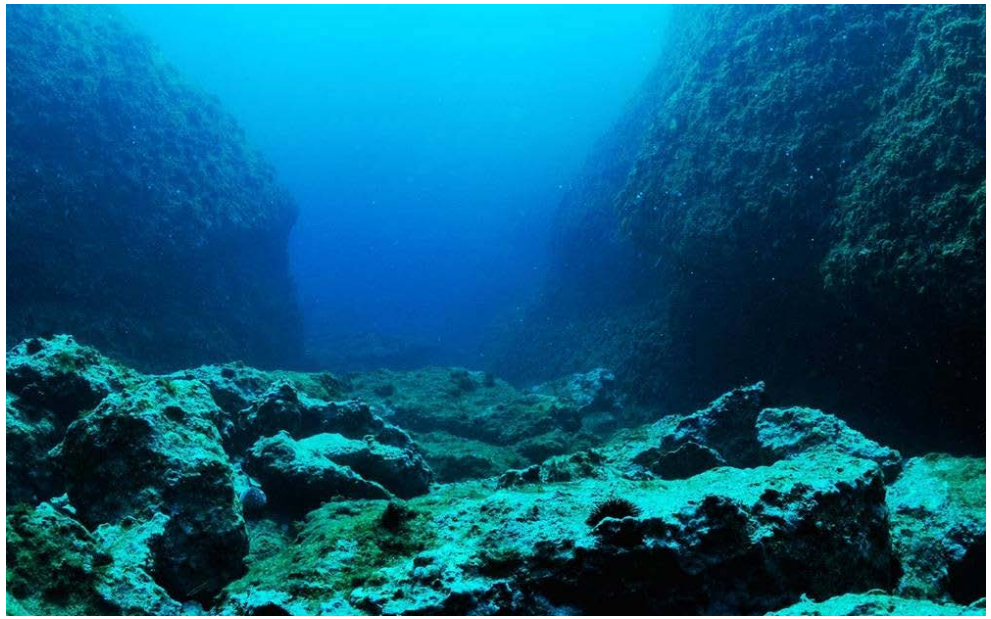


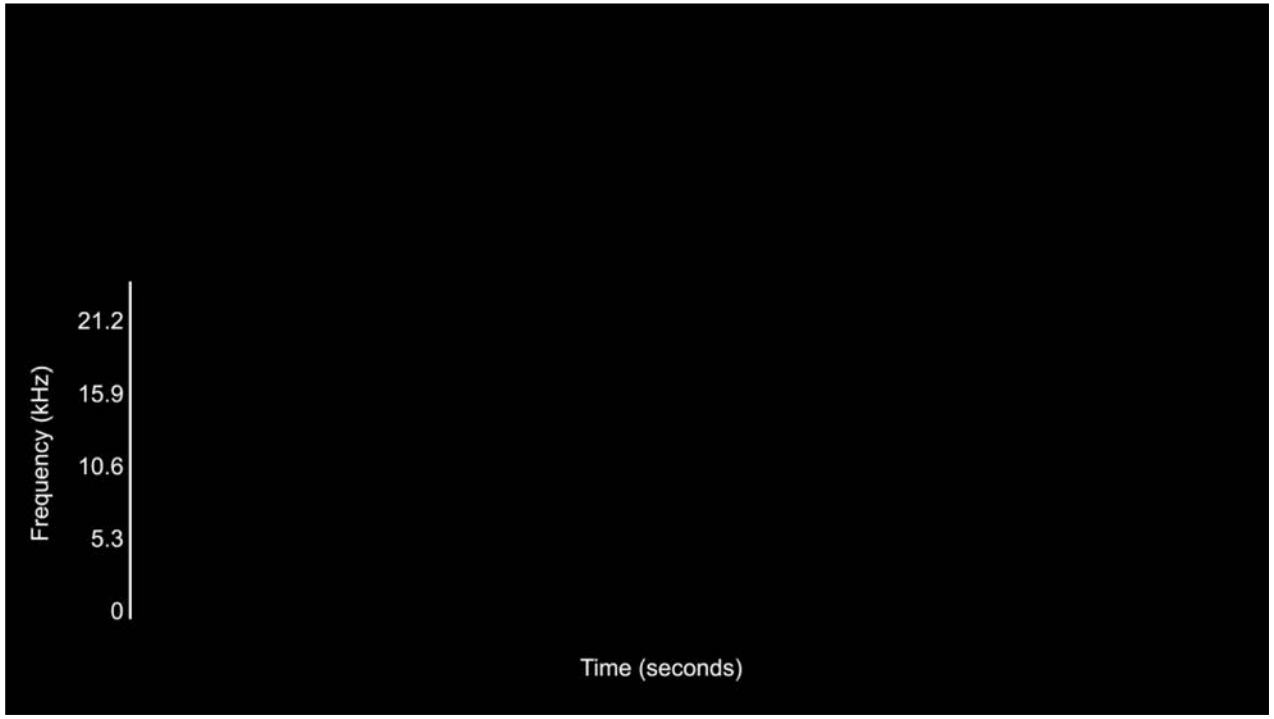

http://www.daviddarling.info/encyclopedia/B/bowhead_whale.html

# Fin whale - Second largest species on Earth



# Earthquake

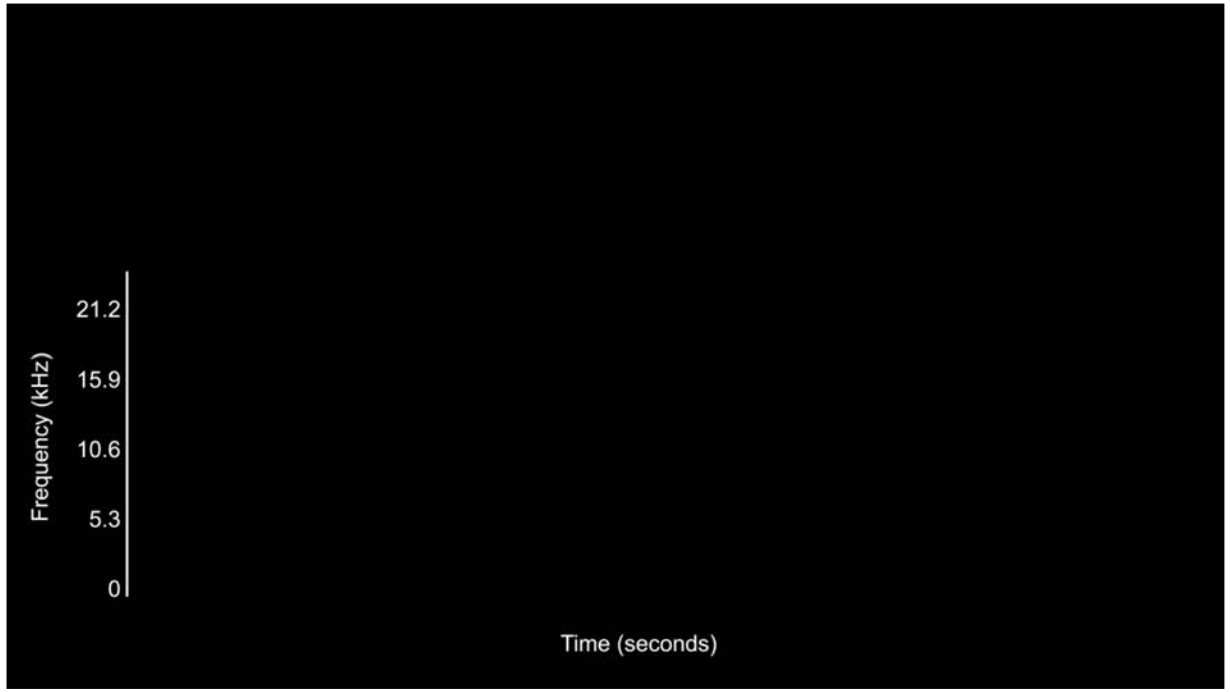





https://dosits.org

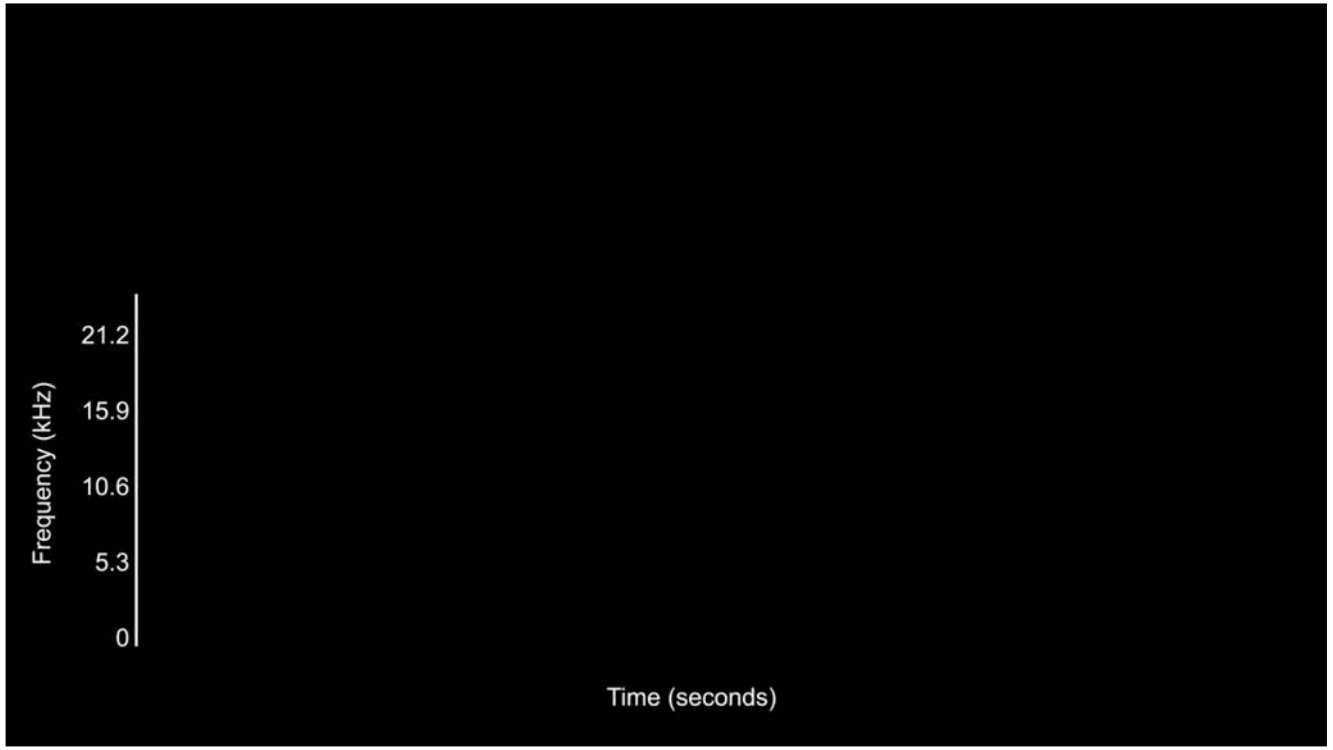
# Iceberg collision with ice shelf

What do you think you hear ???




https://dosits.org

# Merchant vessel

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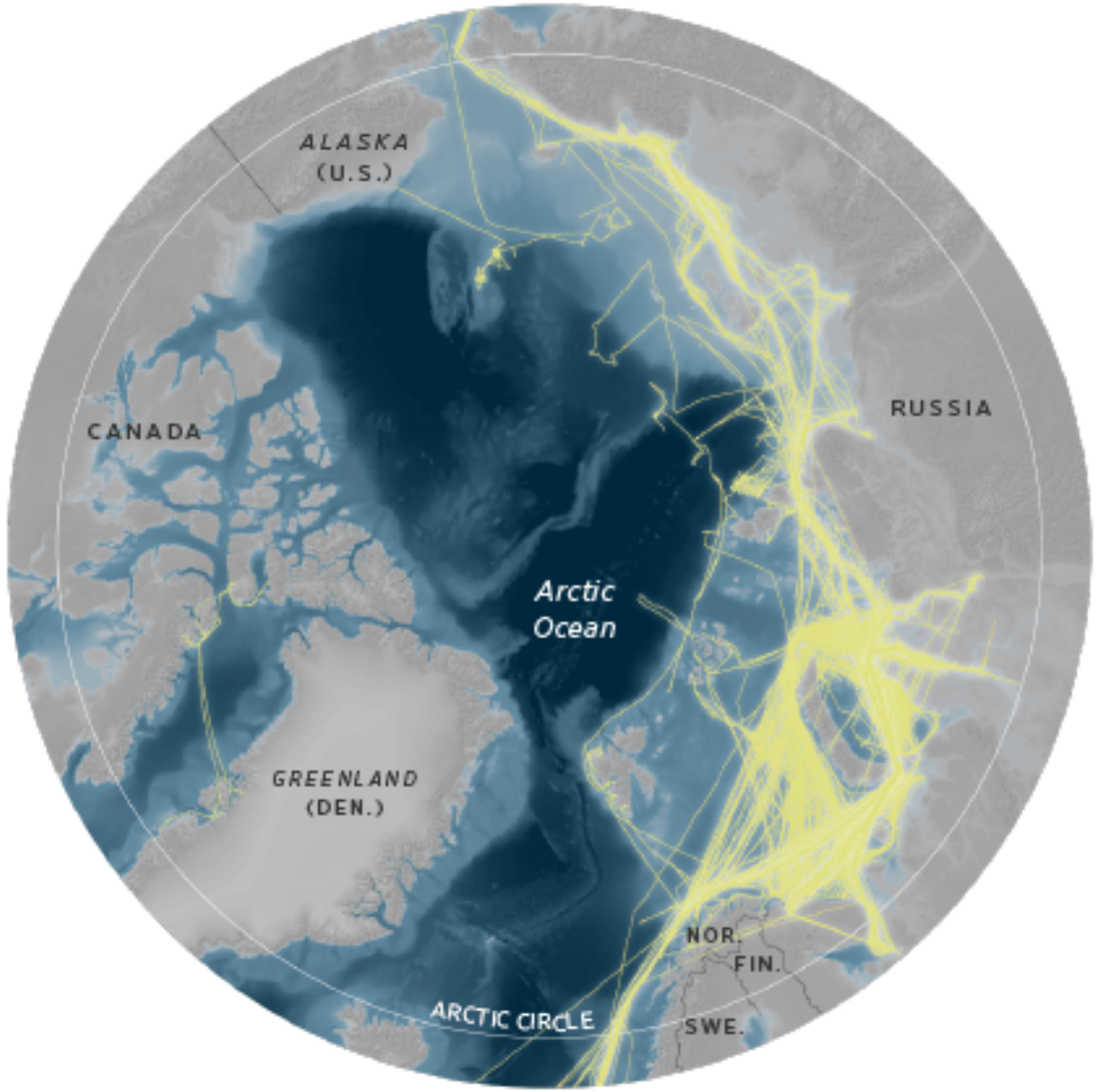
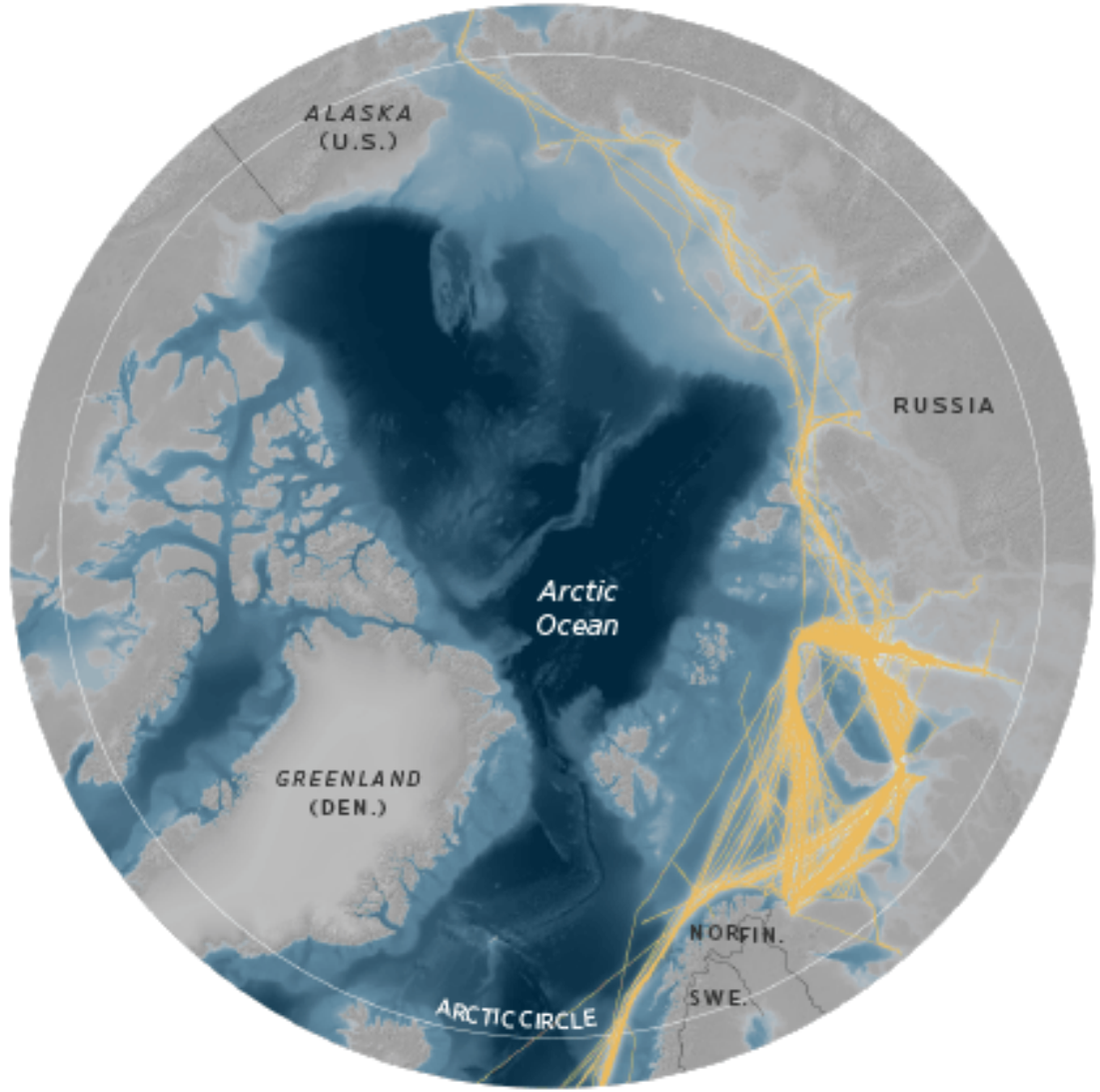
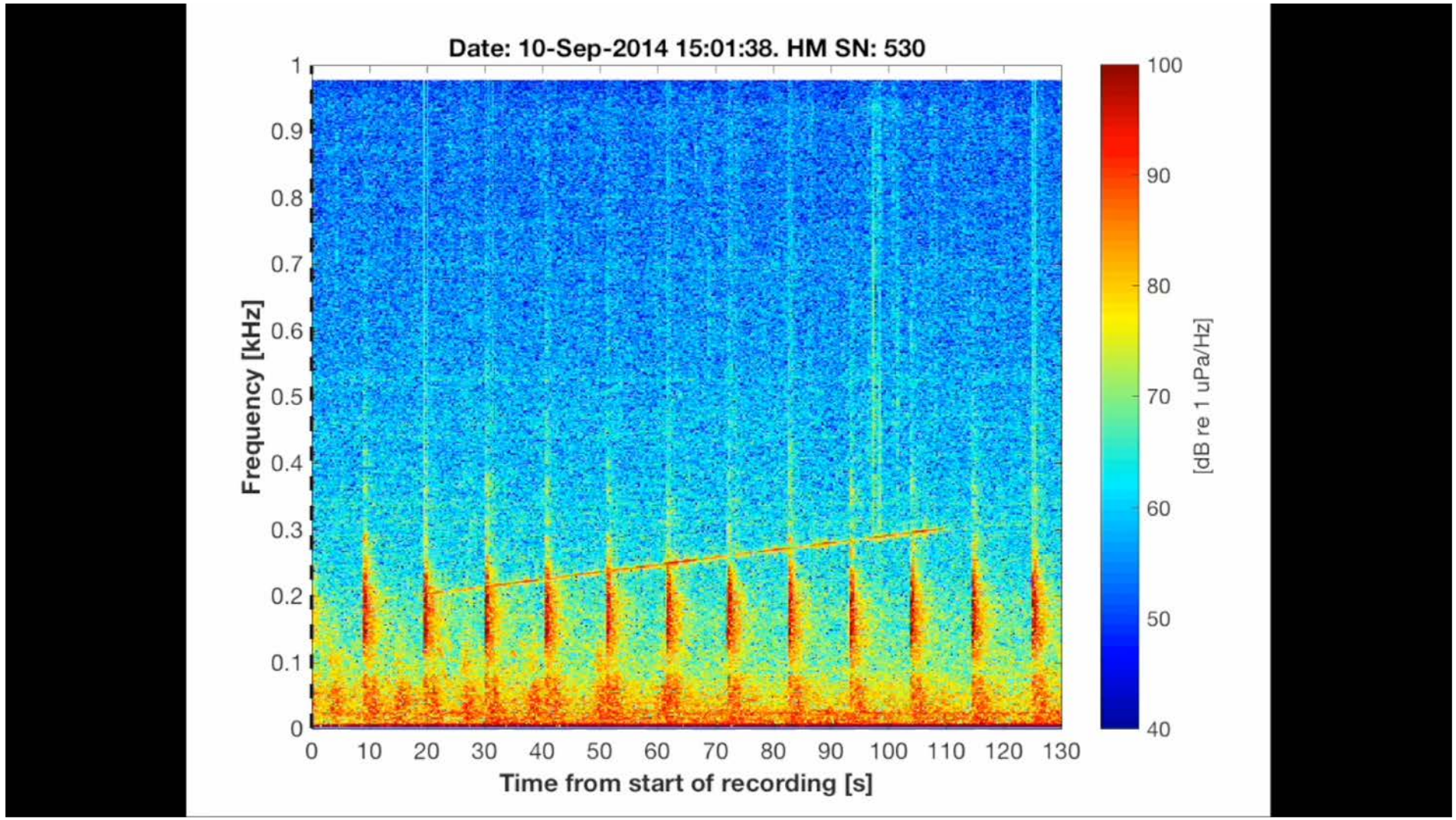



All traffic in the Northern Sea Route in 2018 (through Sept. 30)

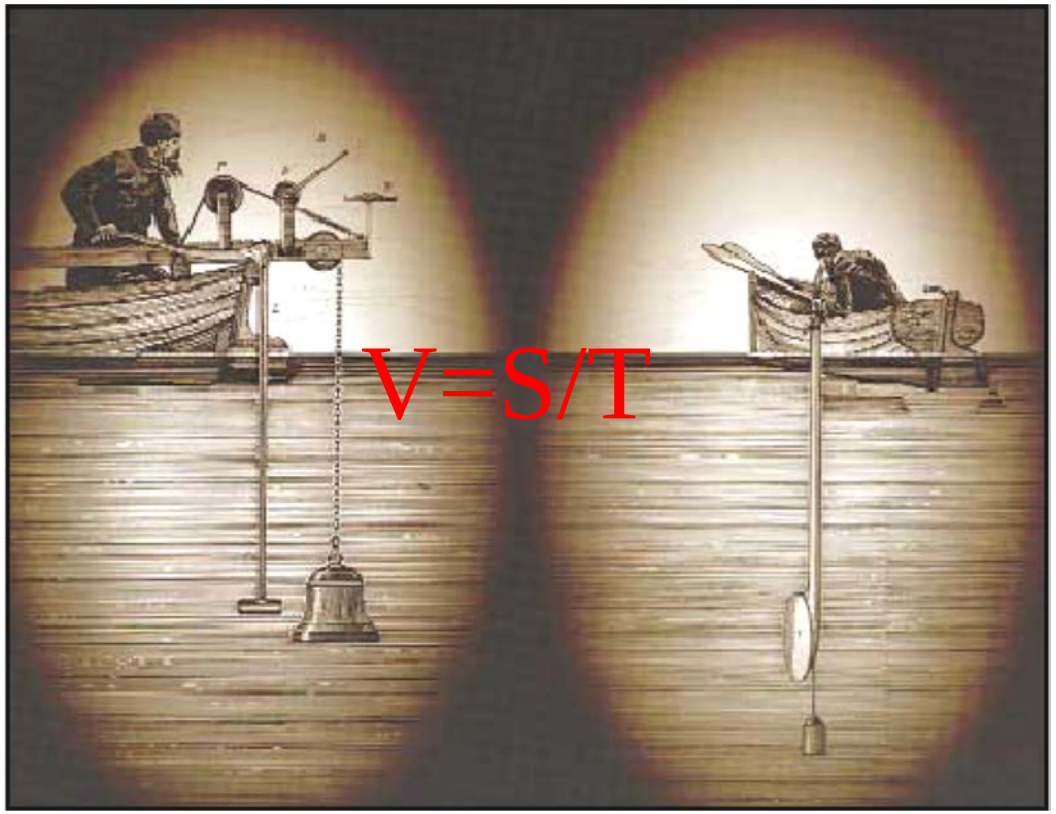



Traffic related to the oil and gas industry

# Seismic airguns and tomography signal



# Measuring sound speed




1826, Colladon and Sturm Lake Geneva

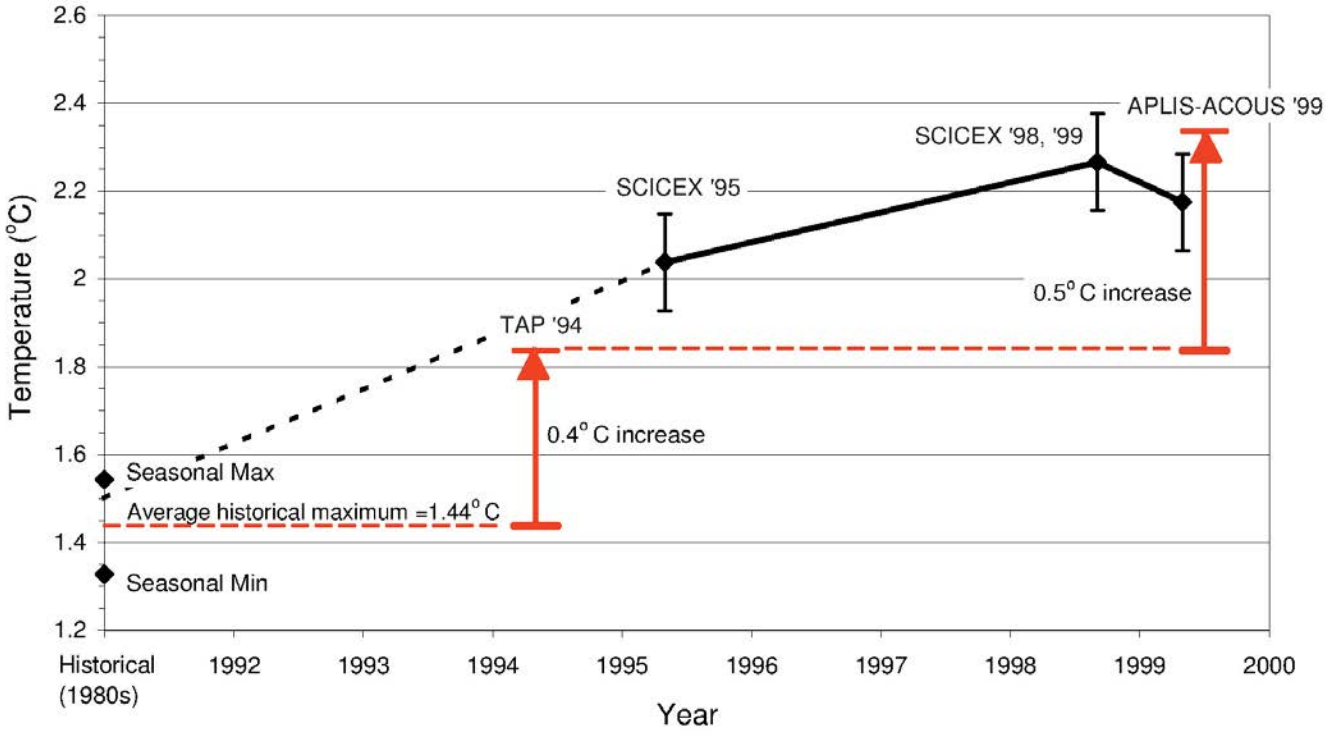
Accurate travel-time measurements between source and receiver– gives sound speed

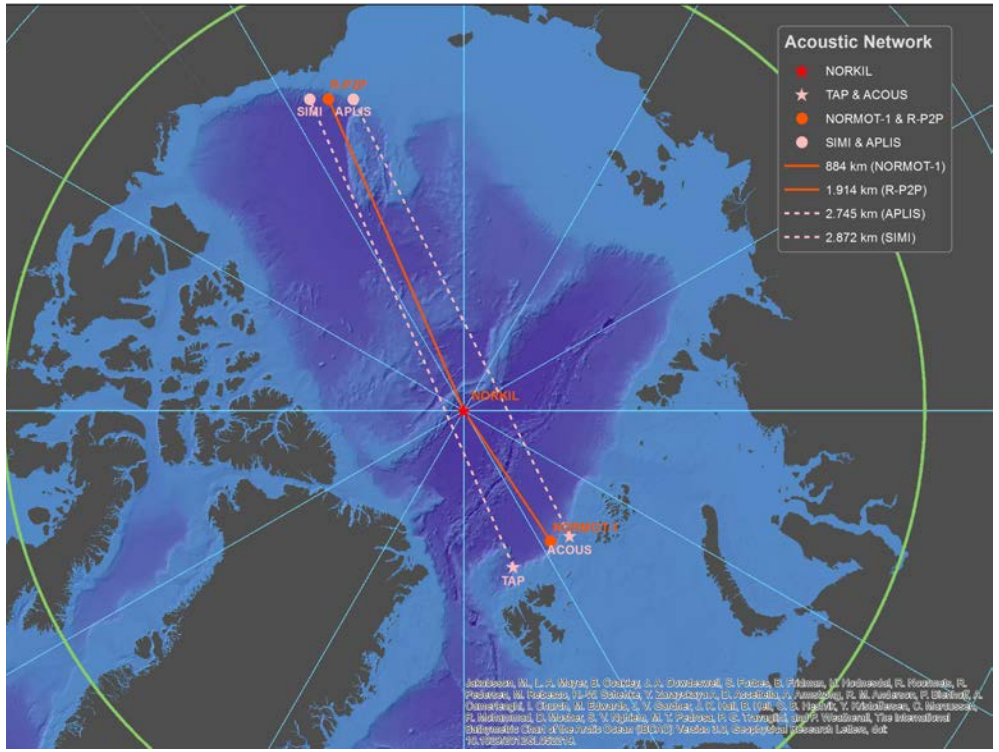
Sound speed varies with temperature, salinity and pressure.

Increase in temperature by 1° C increases the sound speed by 4.0 m/s

→ We can measure temperature!!

# Trans-arctic experiments in 1994 and 1999

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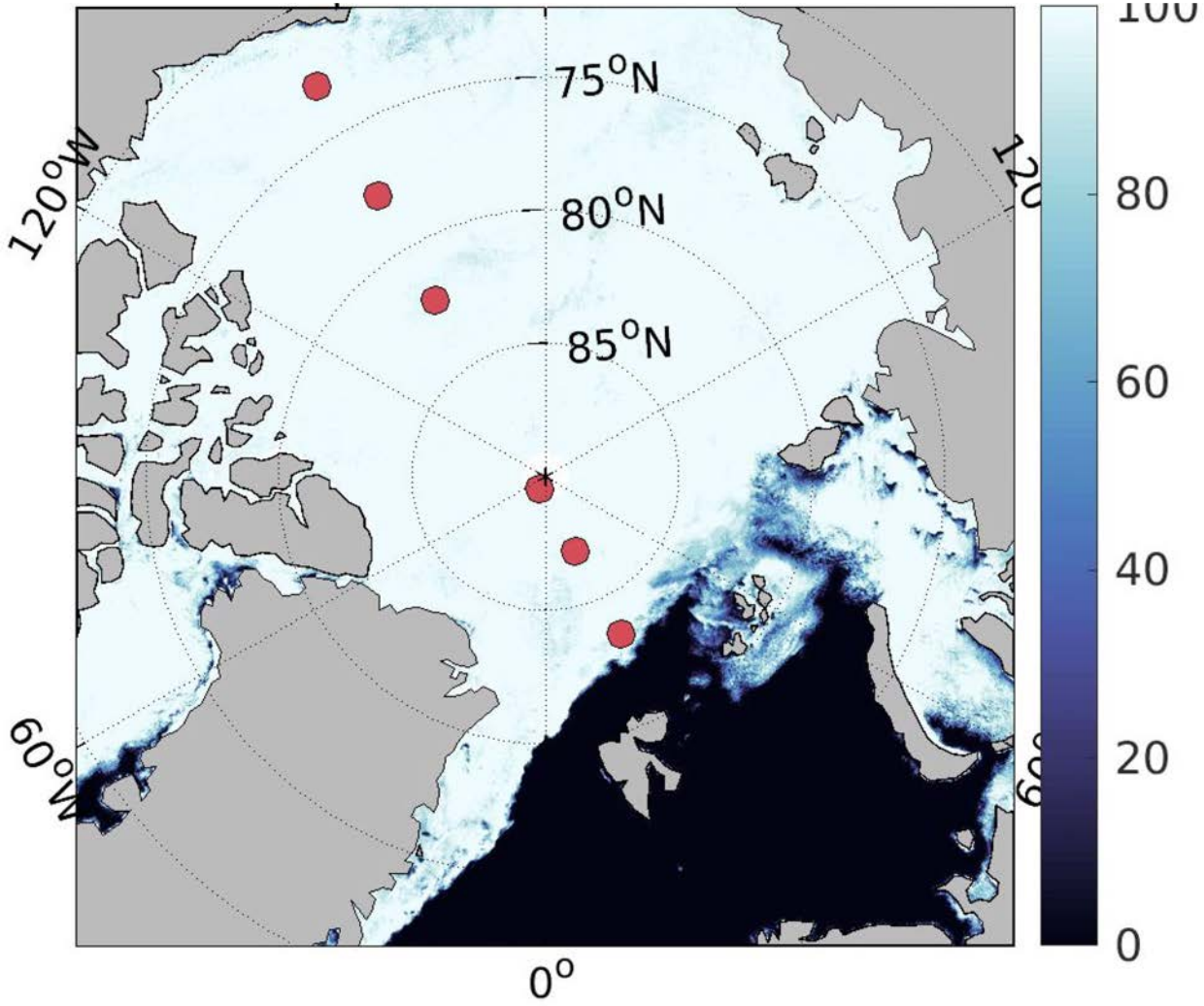
What has happened with the mean ocean temperature in the Arctic Basin ?

# Coordinated Arctic Acoustic Thermometry Experiment (CAATEX)

A joint Norway-USA- Canada project (2018-2022)




The project will use basin-wide acoustic thermometry and local ice-ocean observations in combination with an eddy-resolving ice-ocean model to produce improved ocean state estimates.

This will be used to estimate the Arctic Ocean heat content and to benchmark global climate models.

Norsk Polarinstitutt

Woods Hole Oceanographic Institution

MOSAiC
The 2019/20 Arctic drift experiment

The Research Council of Norway

Scripps Institution of Oceanography

NERSC

The University of Texas at Austin

Office of Naval Research
ONR
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