

Mapping Underwater Noise Footprints for Ship Traffic in the Canadian Arctic



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Underwater Noise from Shipping

Sources:

- **propeller cavitation**
 - engines
 - other operations on board
 - ice breaking
-
- Shipping noise can be very loud
 - Averaging around 175-180 dB re 1 uPa*
 - Reaching levels of 200 dB re 1 uPa or more for ice breaking
 - How loud a ship is varies greatly depending on the size of ship, speed it's traveling, among many other factors.



Photo: The Shipyard

*Note: sound measured with difference reference pressures in water (re 1 uPa) and in air (re 20 uPa)

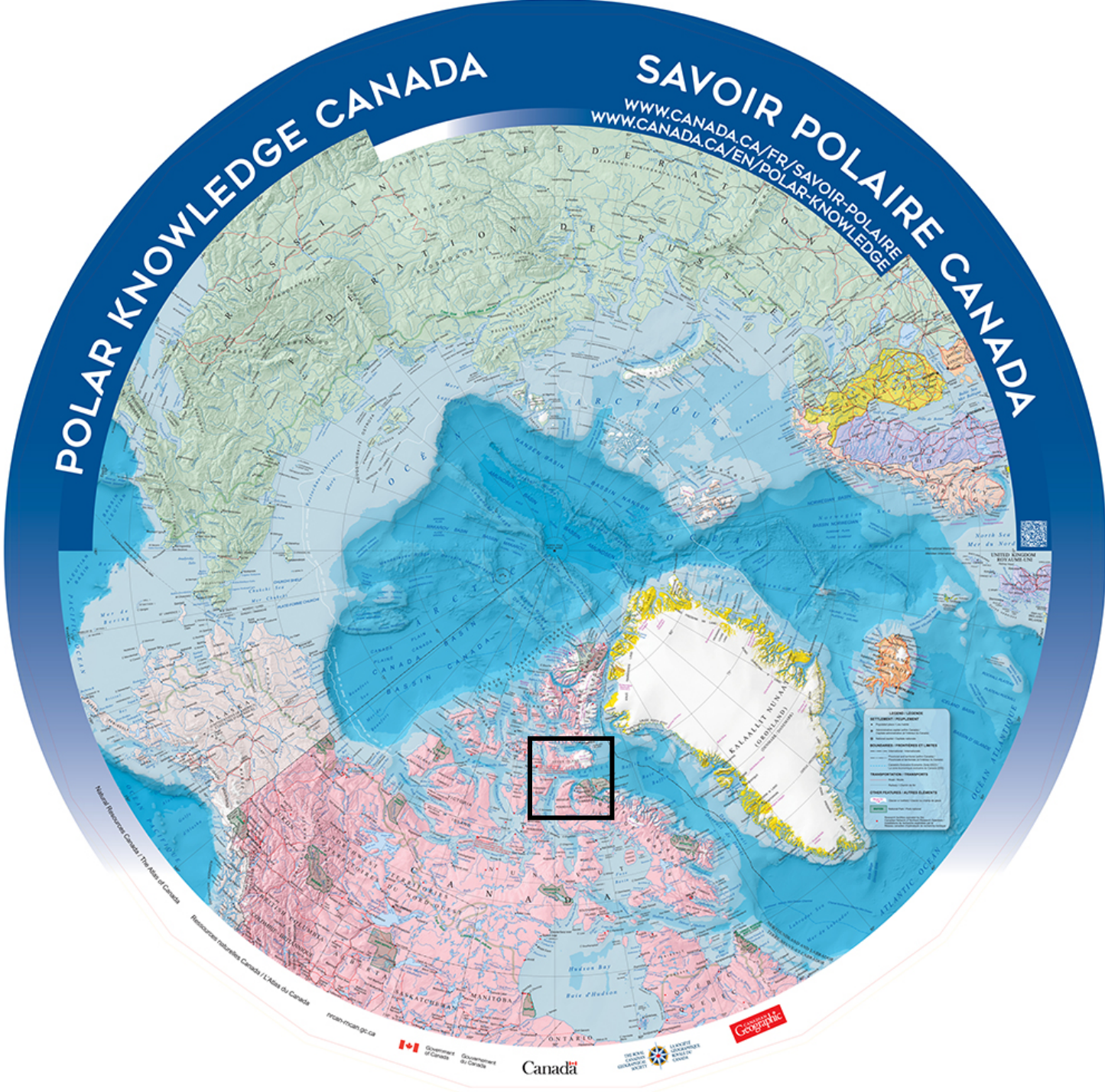
Underwater Noise and Marine Life

Underwater noise causes a variety of issues in marine life:

- Acoustic masking – blocking important acoustic cues from being heard
- Behavioural disturbance
- Hearing damage (temporary or permanent)
- Death:
 - Barotrauma
 - behavioural disturbance leading to a rapid change in depth (the bends/decompression sickness)

Our Goal:

- Build a shipping noise footprint map for the Canadian Arctic/Northwest Passage
 - Complete: Lancaster Sound
 - In progress: Western Arctic (Kitikmeot and Inuvialuit Regions AND the Alaska North Slope)
- Overlay these noise footprints with important areas for marine mammals to estimate noise exposure/risk
- Study Area: the new Tallurutiup Imanga (Lancaster Sound) National Marine Conservation Area in Nunavut, Canada



Noise Metrics

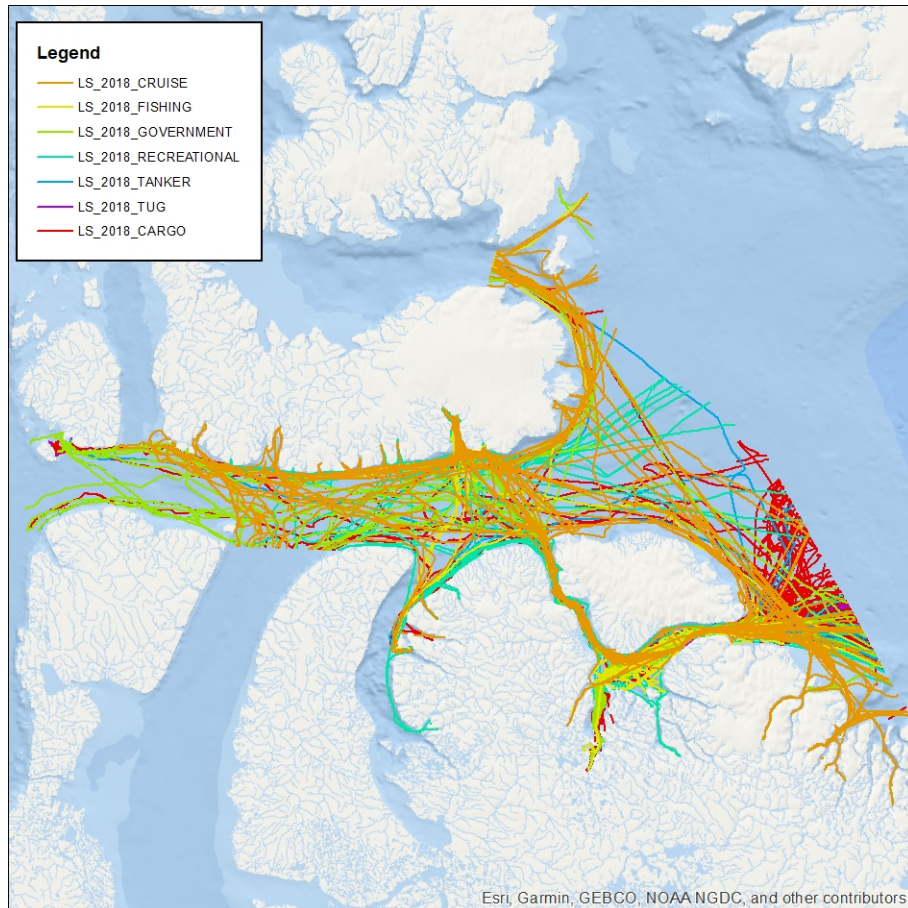
Depends on the question being asked:

- What are the average underwater noise levels in a region?
- What are the maximum underwater noise levels in a region
- Will underwater noise in this region cause:
 - hearing damage?
 - behavioural disturbance?

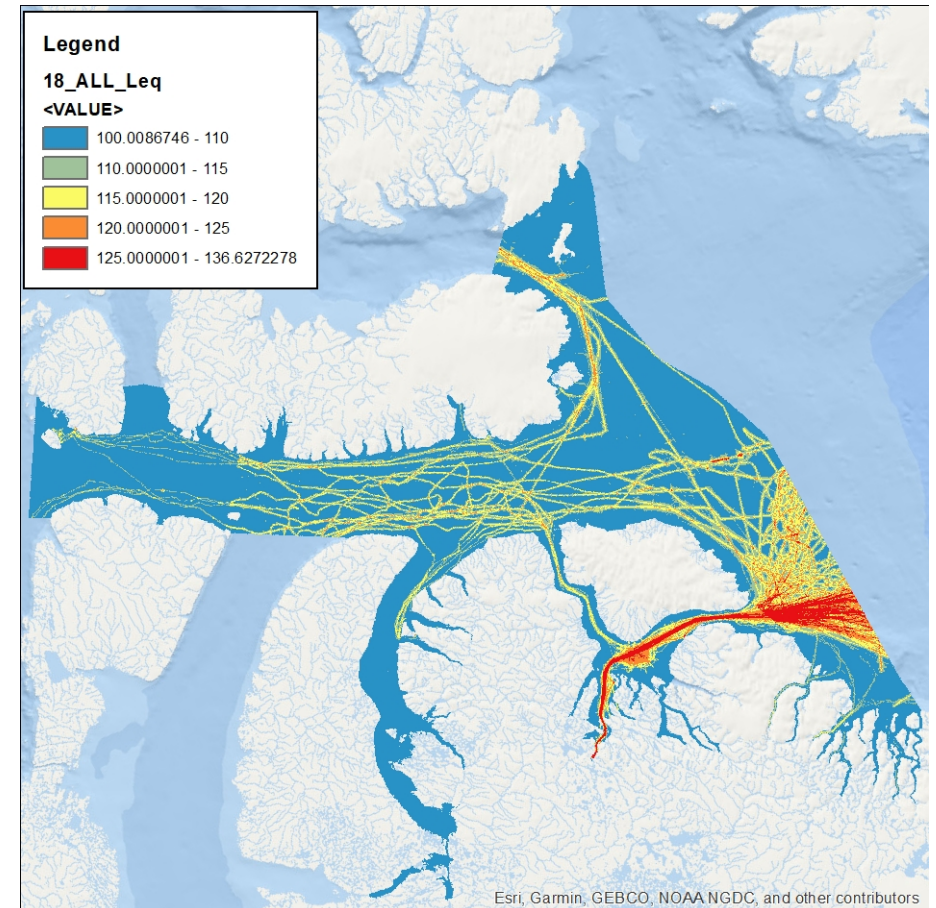
Question	Duration: Short	Duration: Long
Average Noise	RMS Sound Pressure Level	Continuous Equivalent Sound Level
Maximum Noise	Peak-to-Peak Sound Pressure Level	Sound Exposure Level
Behavioural Disturbance	RMS Sound Pressure Level	How often threshold is surpassed, or Continuous Equivalent Sound Level
Hearing Damage	Instantaneous Maximum Noise	How often threshold is surpassed

Methods Overview:

How to get from ships tracks to a ship noise footprint



2018 AIS Ship Tracks



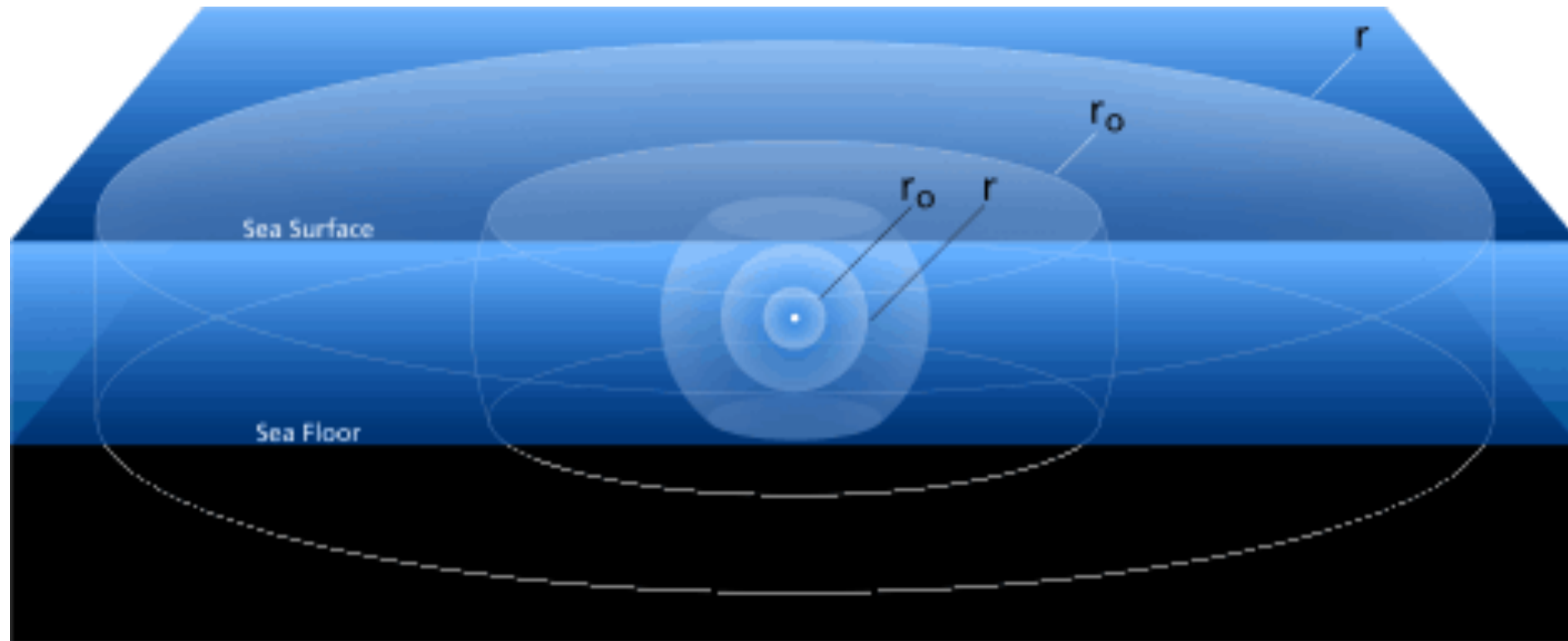
2018 Noise Footprint

Methods Overview:

- Acoustic propagation modeling: assess transmission loss throughout area of interest
- Ship tracking data (AIS): calculate ship density and distance to nearest ship
- Apply transmission loss to ship distance and density data, account for different source levels of ships
- Calculate different metrics of noise footprints, such as by ship class, monthly, or yearly levels, at different spatial resolutions, or based on different hearing bandwidths.

Acoustic Propagation Modeling

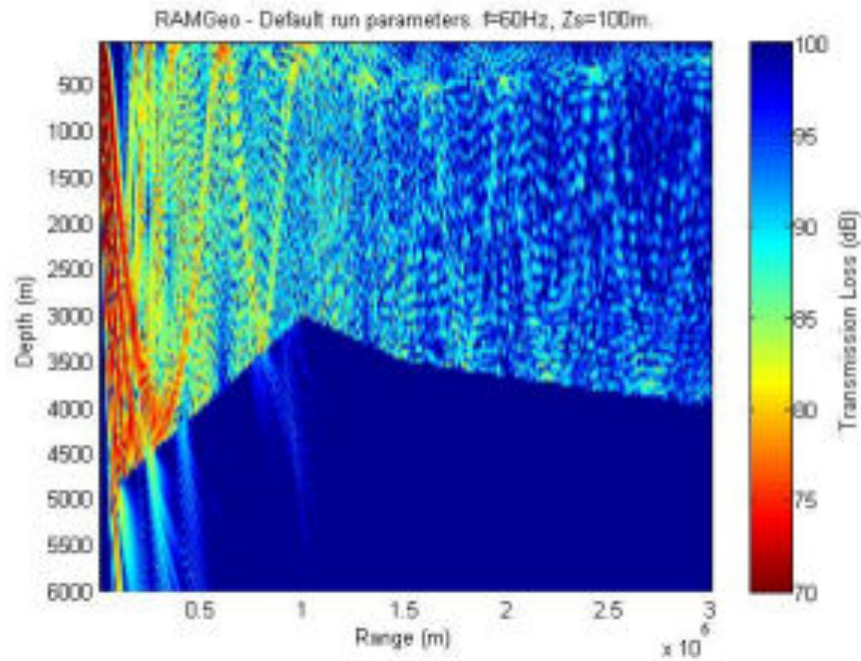
- Transmission Loss = $10 \log R$ or $20 \log R$? Not really...



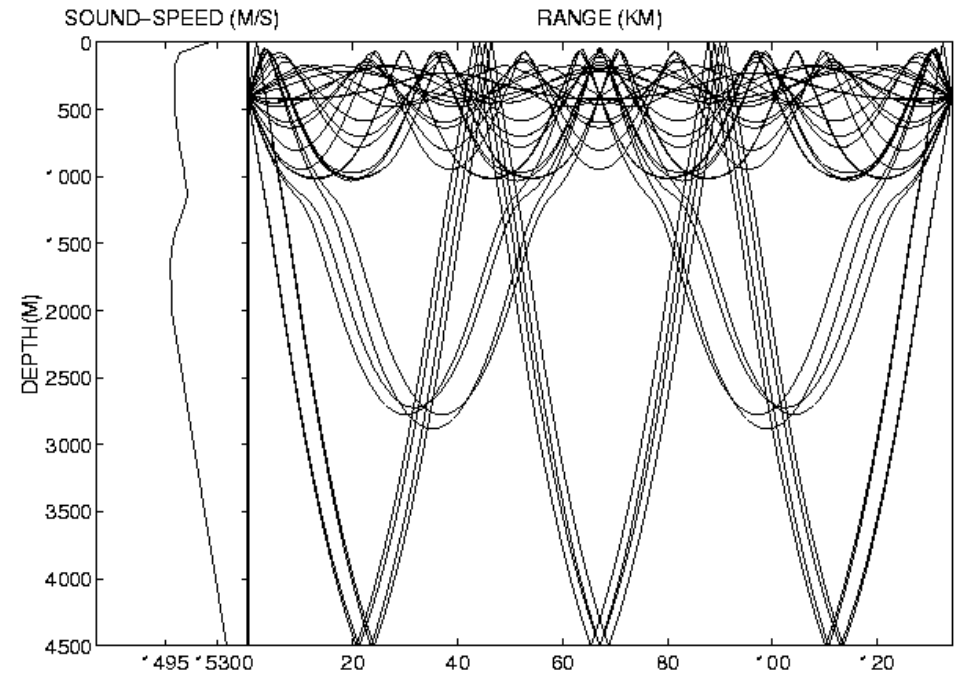
Acoustic Propagation Modeling

Acoustic signals travel like a wave – ray tracing

Water chemistry, bathymetry, and bottom sediment are important factors.

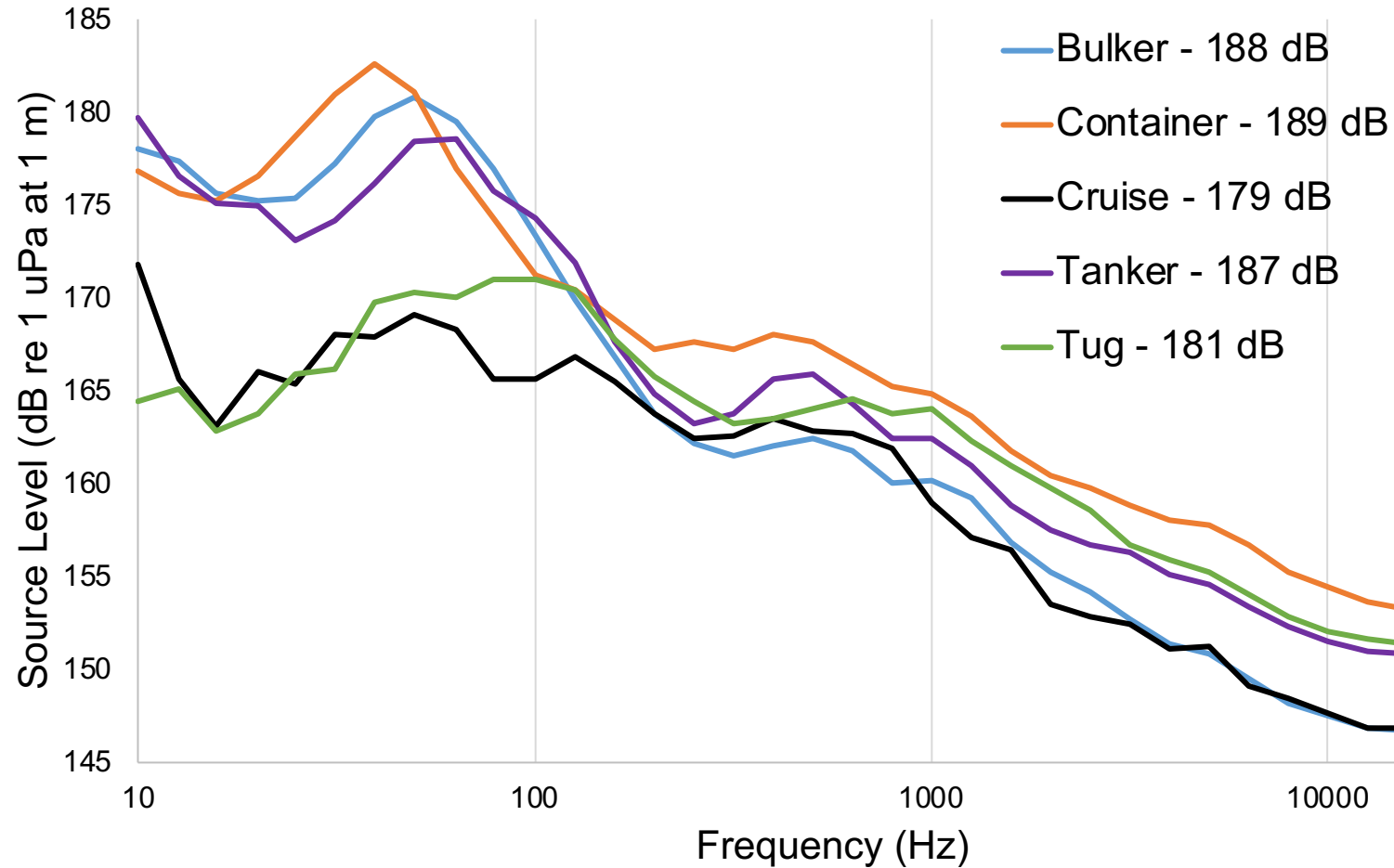


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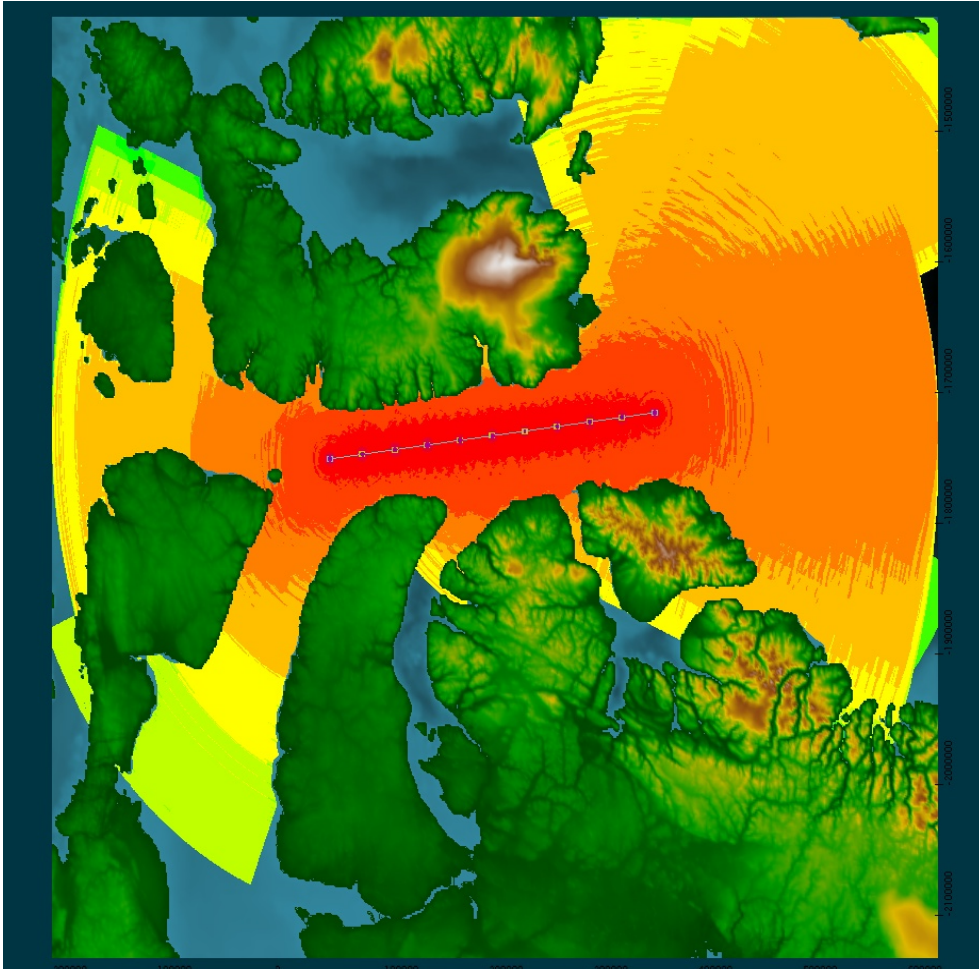


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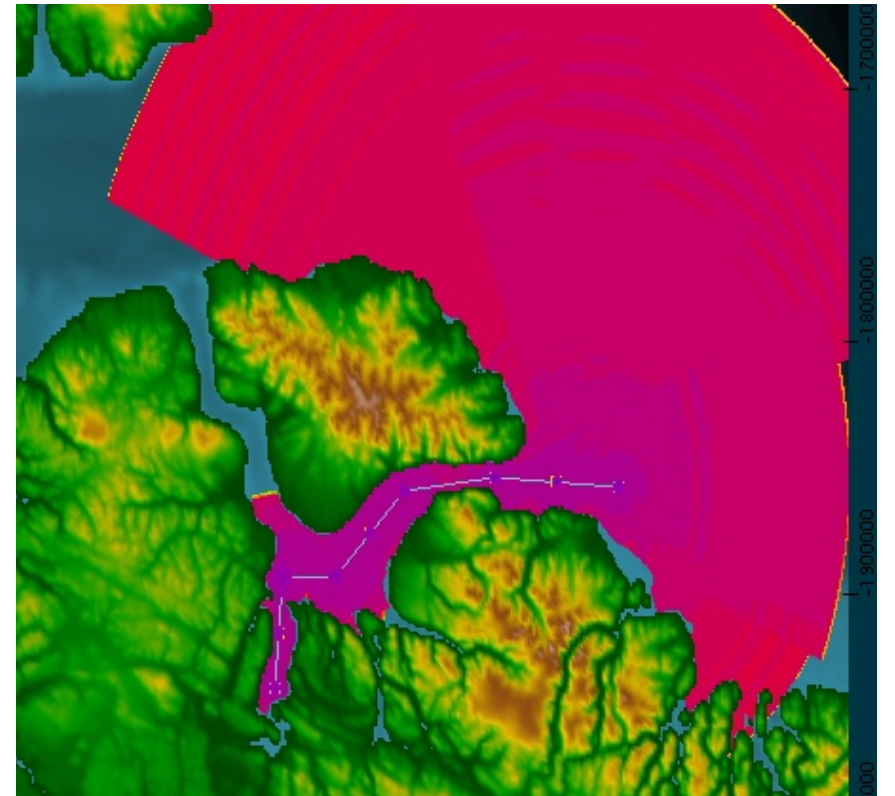
Vessel Source Levels



Acoustic Propagation Modeling Lancaster Sound, Nunavut, Canada



Parry Passage: Deep, straight channel; relatively low variability

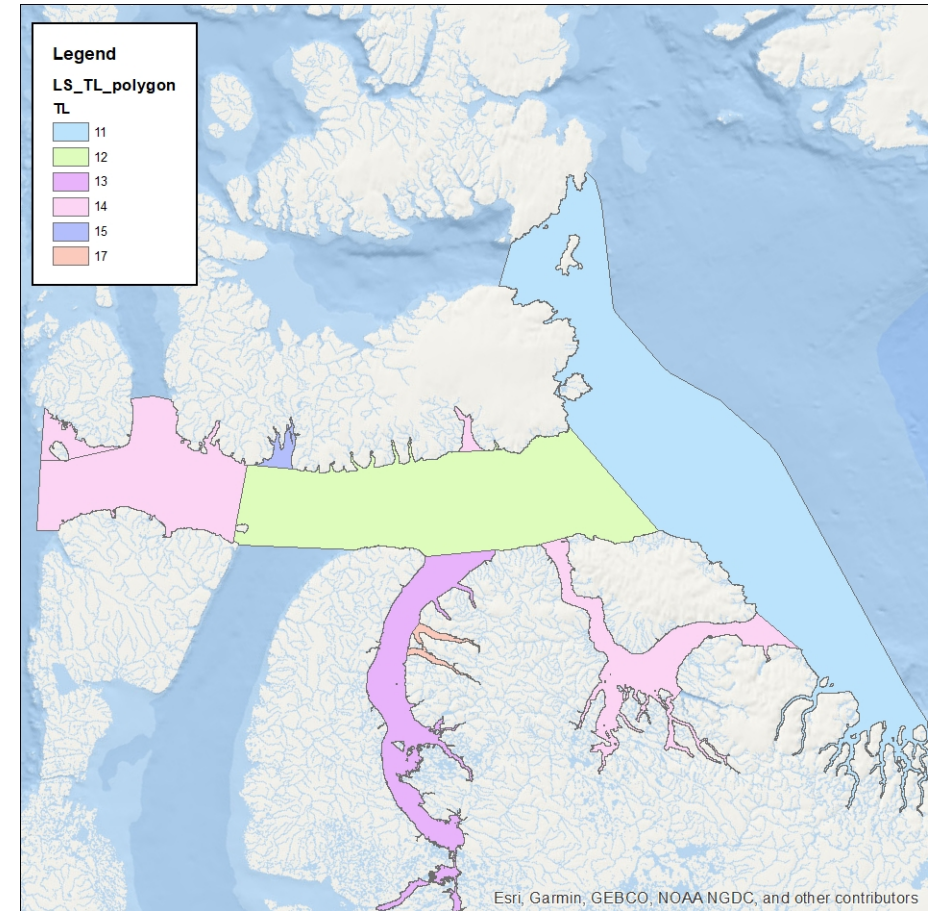


Eclipse Sound: Narrow channel and wide inlet, varying depth; high variability

Acoustic Propagation Modeling Lancaster Sound, Nunavut, Canada

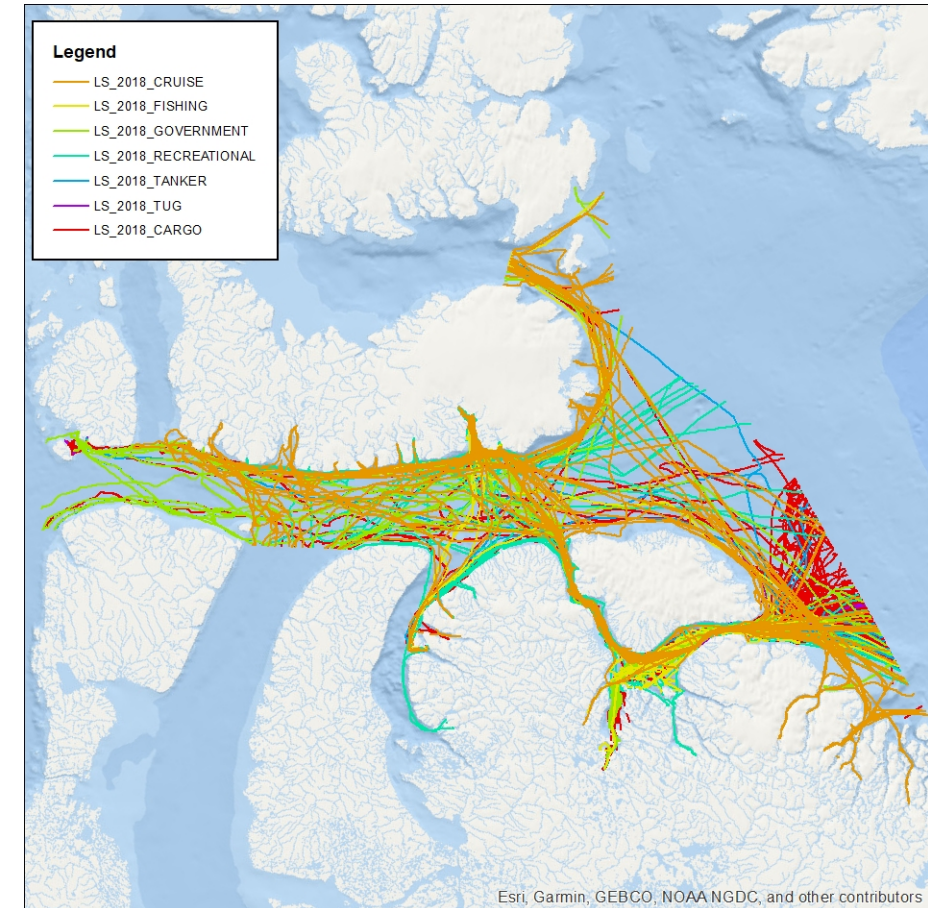
- Different zones of transmission loss in Lancaster Sound

Area	Transmission Loss (X Log R)
Baffin Bay (very deep and wide)	11
Parry Passage	12
Admiralty Inlet	13
Barrow Strait, Eclipse Sound, Resolute, Various Narrow Inlets	14
Maxwell Bay (narrow, shallow inlet)	15
Nanisivik, Arctic Bay	17

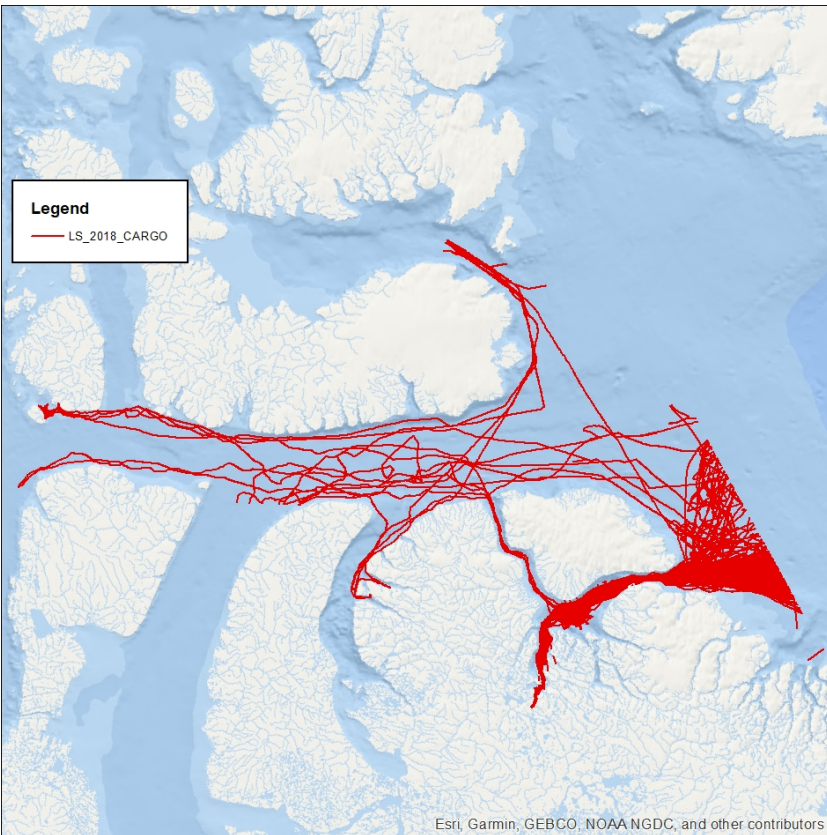


Ship Tracking Data

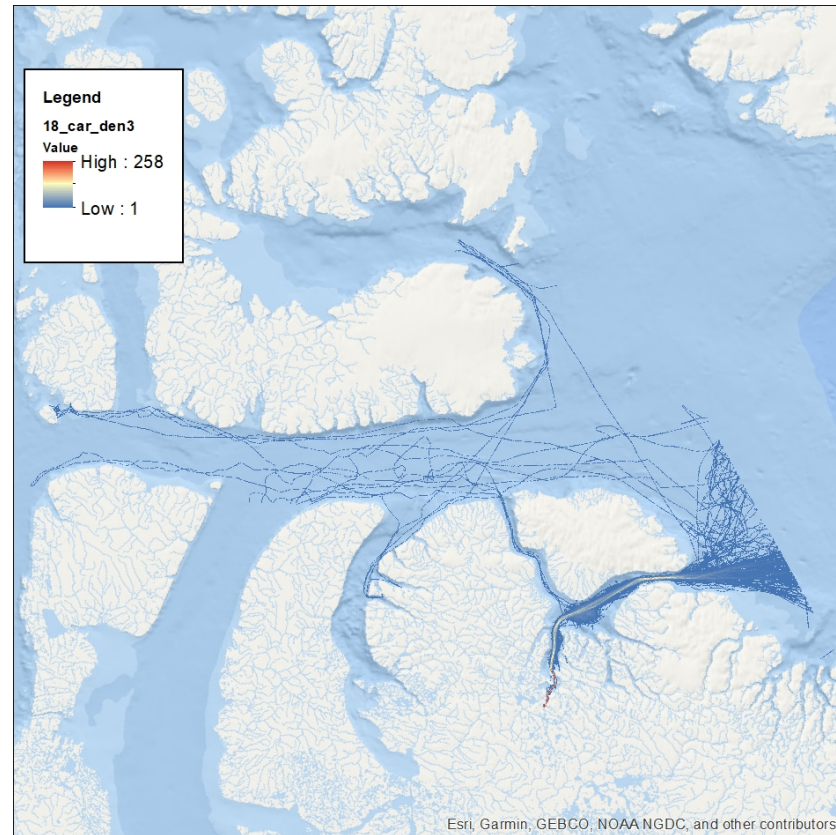
- Satellite AIS (automatic identification system) data from exactEarth
- Straight lines fitted between points, with least distance going around land (i.e. islands)
- For each vessel class in each year between 2015 and 2018:
 - Calculated a density grid in ArcGIS with 500 m resolution
 - Calculated the distance to the nearest ship for each grid cell



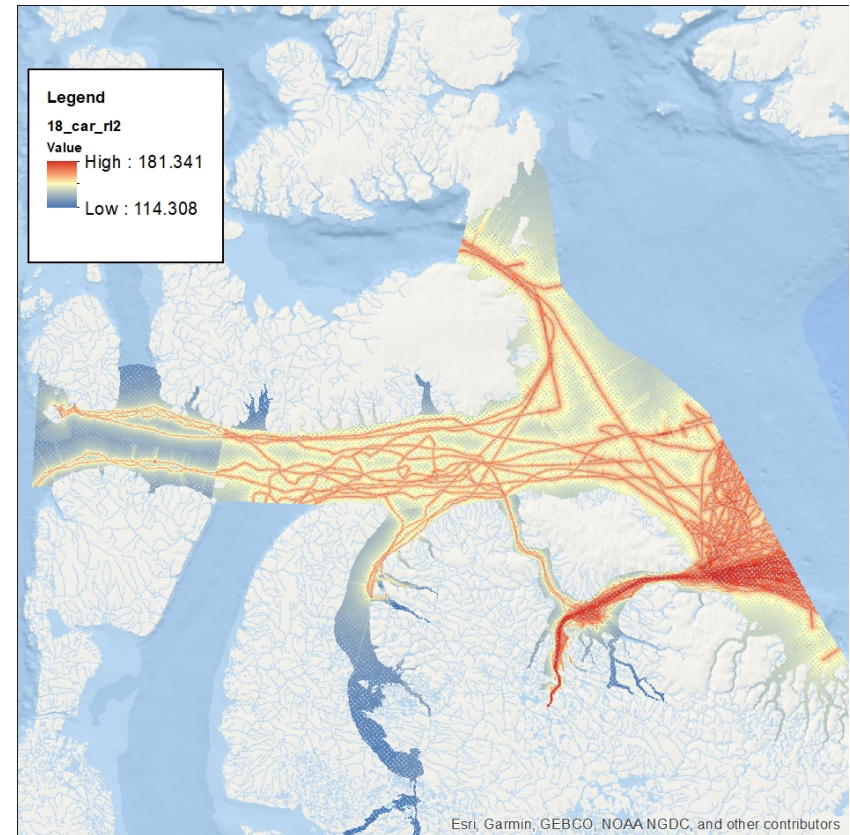
Noise Footprint – Cargo Ships in 2018



2018 AIS Cargo Ship Tracks



2018 Cargo Ship Density, 500 m res



2018 Cargo Ship Received Level (dB)

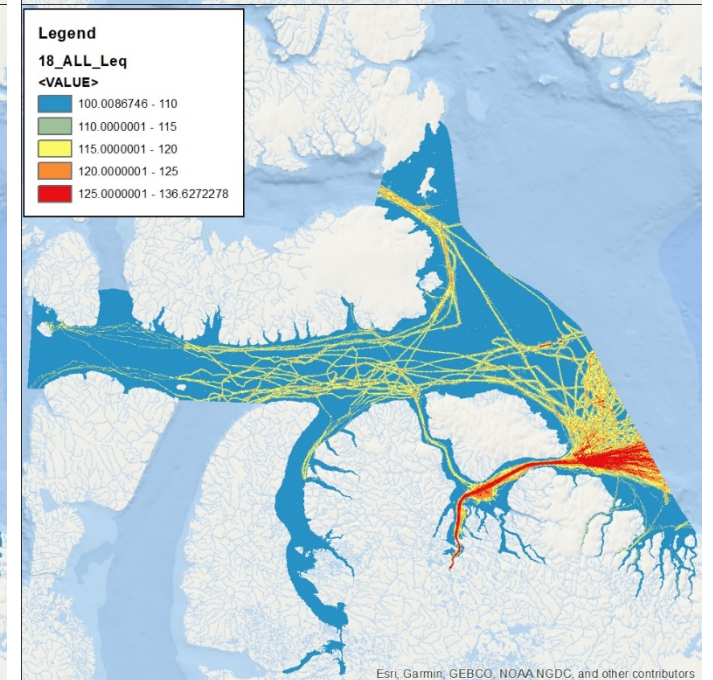
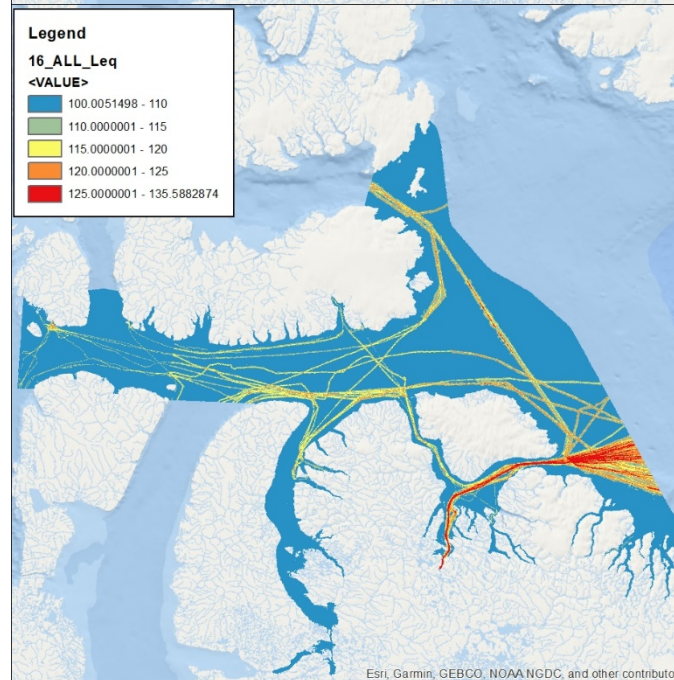
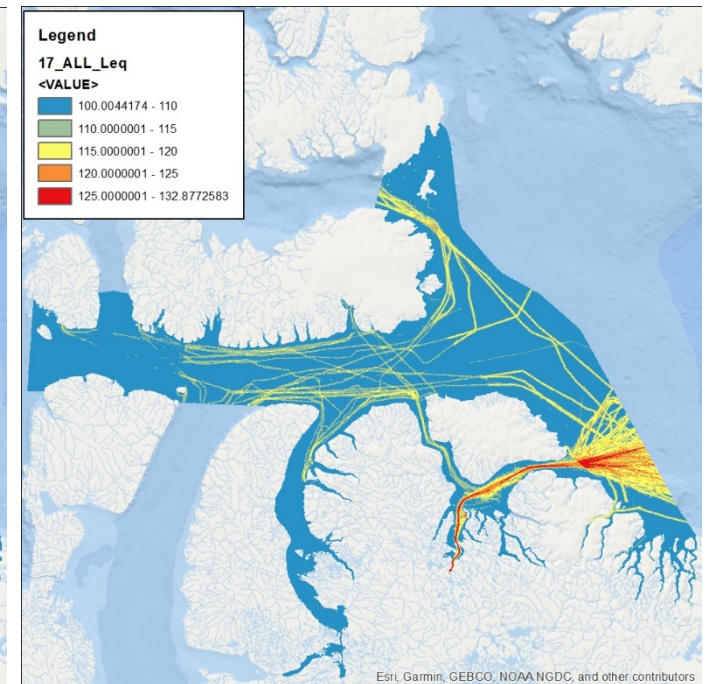
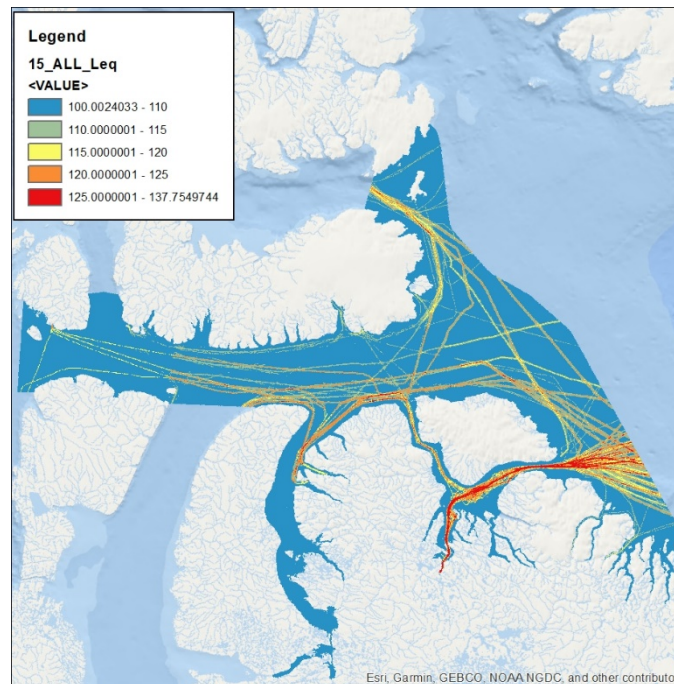
Leq: Continuous Equivalent Sound Level: 2015-2018

Legend:

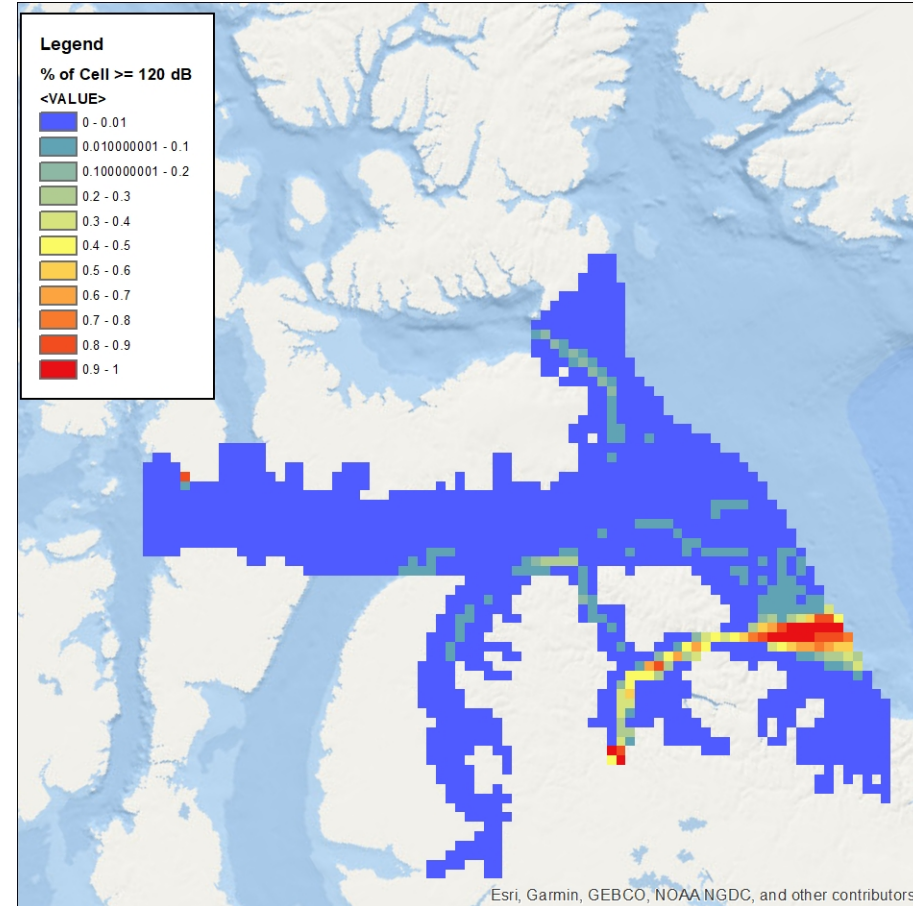
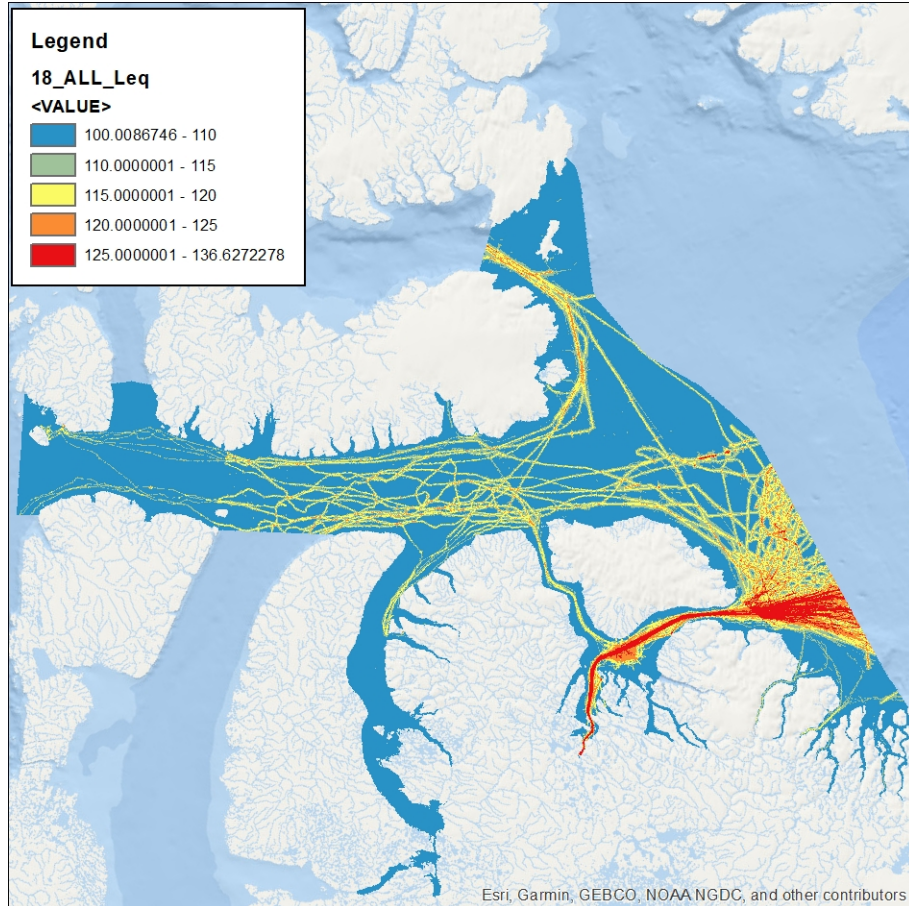
Blue = not above ambient sound level
Orange and red = above the NOAA 120 dB threshold for disturbance to marine mammals.

Summary:

- Consistently high Leq in Eclipse Sound due to ships from Baffinland Iron Ore Mine (1 or more ships per day).
- High variability between years
- Smaller boats (fishing, recreation) and military ships have almost no impact on this metric



Spatial Resolution: 500 m vs 10 km.



Thanks!

- Ship source level data provided by the Port of Vancouver, Transport Canada, Jasco Applied Sciences Ltd, and Oceans Network Canada
- Satellite AIS data provided by exactEarth through the MEOPAR network in Canada, then processed by Zuzanna Kochanowicz in Jackie Dawson's lab at the University of Ottawa
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