Curtin University

Modelling Cumulative Underwater Noise from Shipping in British Columbia

Dr. Christine Erbe
Centre for Marine Science & Technology
Curtin University, Perth, Australia
C.Erbe@curtin.edu.au
Dr. Rob Williams, Sea Mammal Research Unit
St. Andrews University, Scotland
Alex MacGillivray, JASCO Applied Sciences, Canada

WWF

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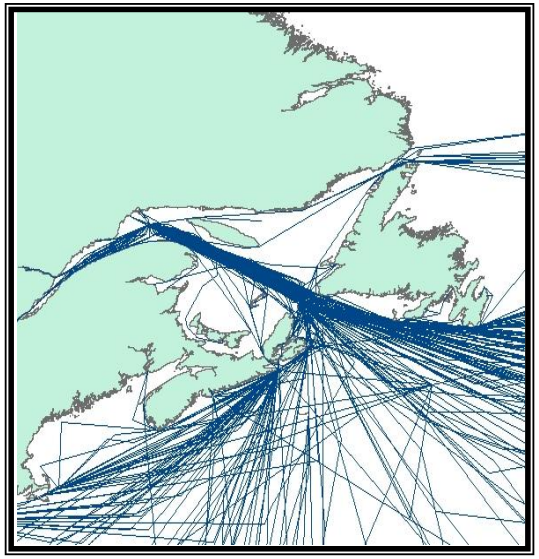

Maritime Activity & Risk Investigation Network

MARIN Report: #2011-01

Traffic Data Preparation for the Oil in Canadian Waters Project

Prepared By:

Hilliard, R.C.; Pelot, Dr. Ronald

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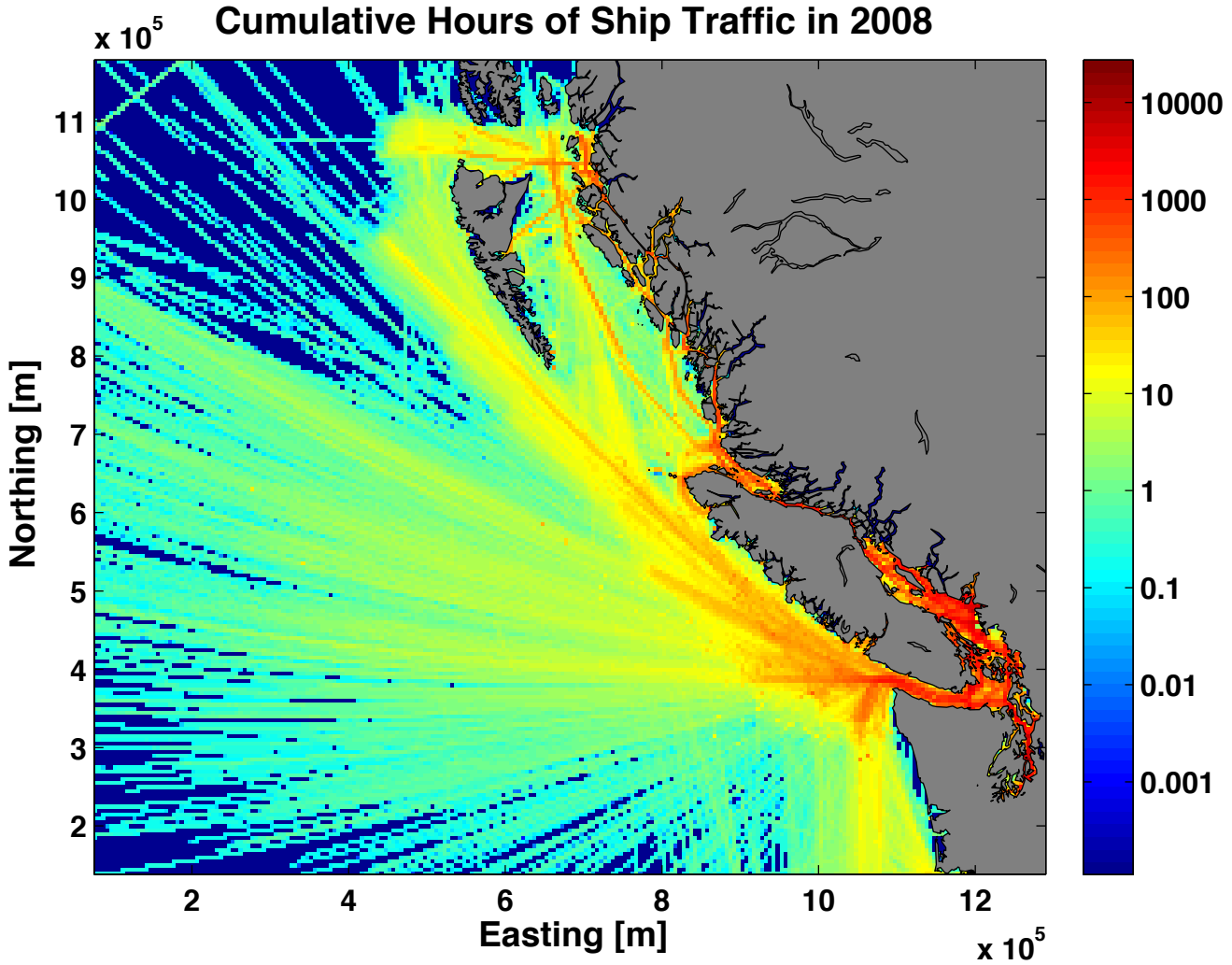
Environment Canada Environnement Canada

Sponsors

Transport Canada Transports Canada

Dr. Ronald Pelot
Department of Industrial Engineering
Ronald.Pelot@dal.ca
www.marin-research.ca

Hours of Ship Traffic in 2008



How do we translate this ship traffic map into a noise map?

1. Group ships into classes
2. Assign source spectra to classes
3. Characterise the environment
4. Model transmission loss
5. Accumulate energy
6. Error analysis
7. Future work

1. Ship Classes

L1	length <= 10m
L2	length >10m and <=25m
L3	length >25m and <=50m
L4	length >50m and <=100m
L5	length >100m and <=200m
L6	length >200m and <=290m
L7	length >290m

T1	passenger / cruise vessels
T2	fishing vessels
T3	government vessels
T4	pleasure vessels and yachts
T5	merchant (bulk / cargo) vessels
T6	tanker vessels
T7	research vessels

2. Source Spectra

Research Ambient Noise Directionality (RANDI) model
(Wagstaff 1973; Breeding et al. 1996):

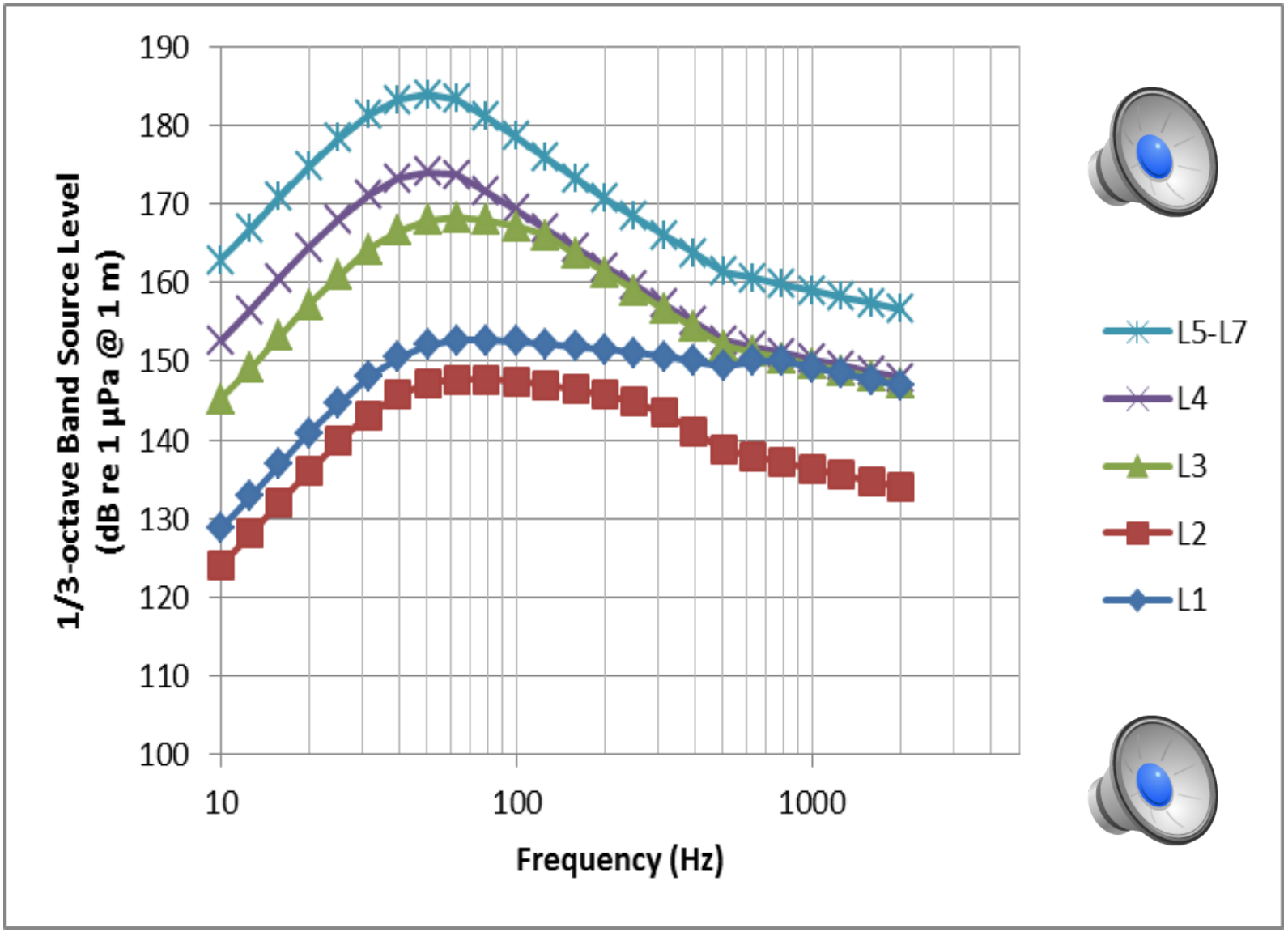
Cv = 6; Cl = 2; Vo = 12 kt; l0 = 300 ft

$$L_s(f,v,l) = L_{s0}(f) + c_V \times 10\log_{10}(v/v_0) + c_L \times 10\log_{10}(l/l_0) + g(f,l)$$

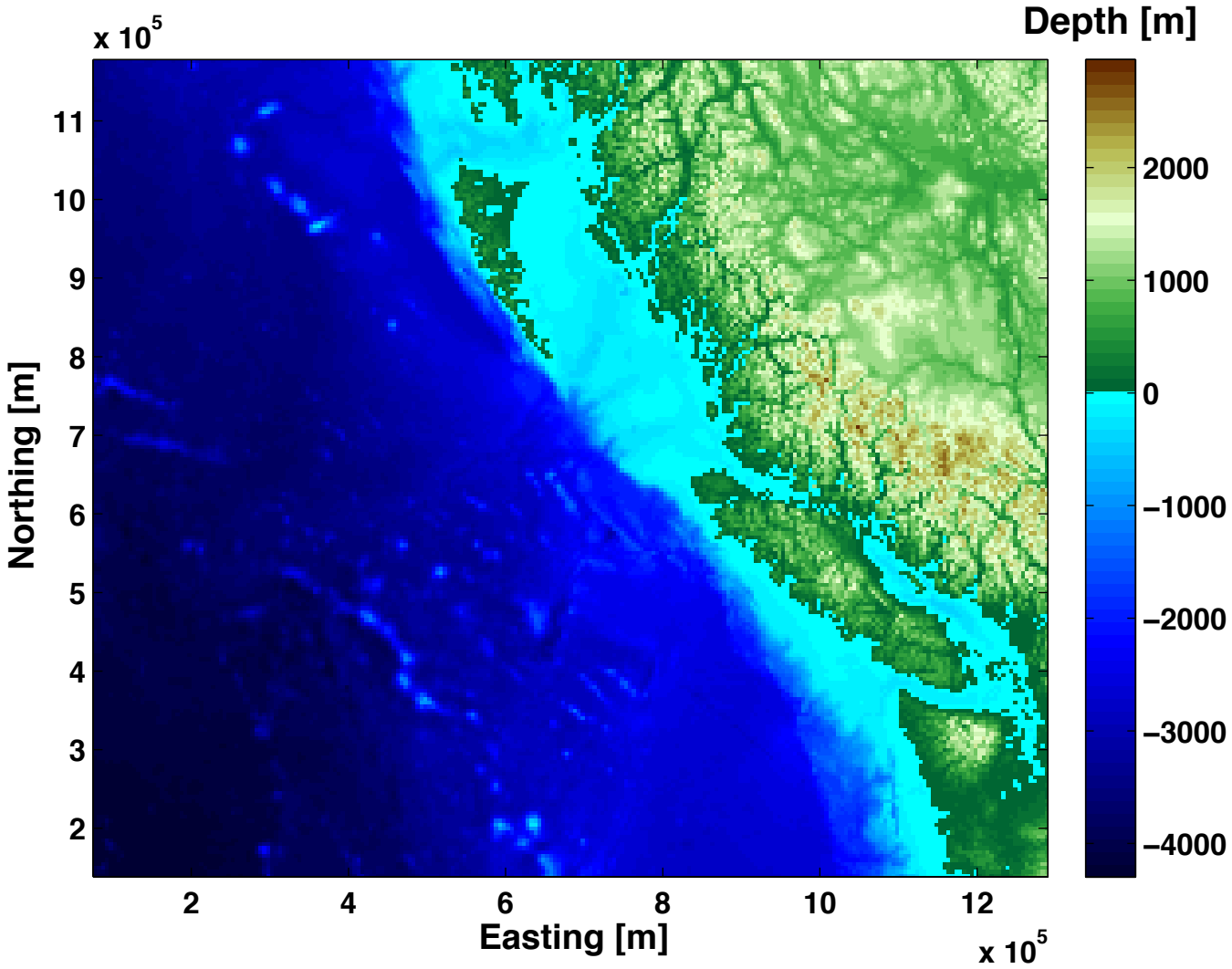
(McKenna et al. 2012)

Vessel Class	L1	L2	L3	L4	L5–L7
Lengths represented (m)	≤ 10	10-25	25-50	50-100	≥ 100
Modelled length (m)	7.8	18.6	38.9	77.8	155.6
Modelled speed (kts)	15.6	9.1	14.6	13.6	15.0
Modelled source depth (m)	0.5	1.25	3.0	6.0	6.0
Broadband SL (dB re 1 µPa @ 1 m)	163.6	157.2	176.4	181.1	190.8

(Brekhovskik & Lysanov 2003; Erbe 2002)

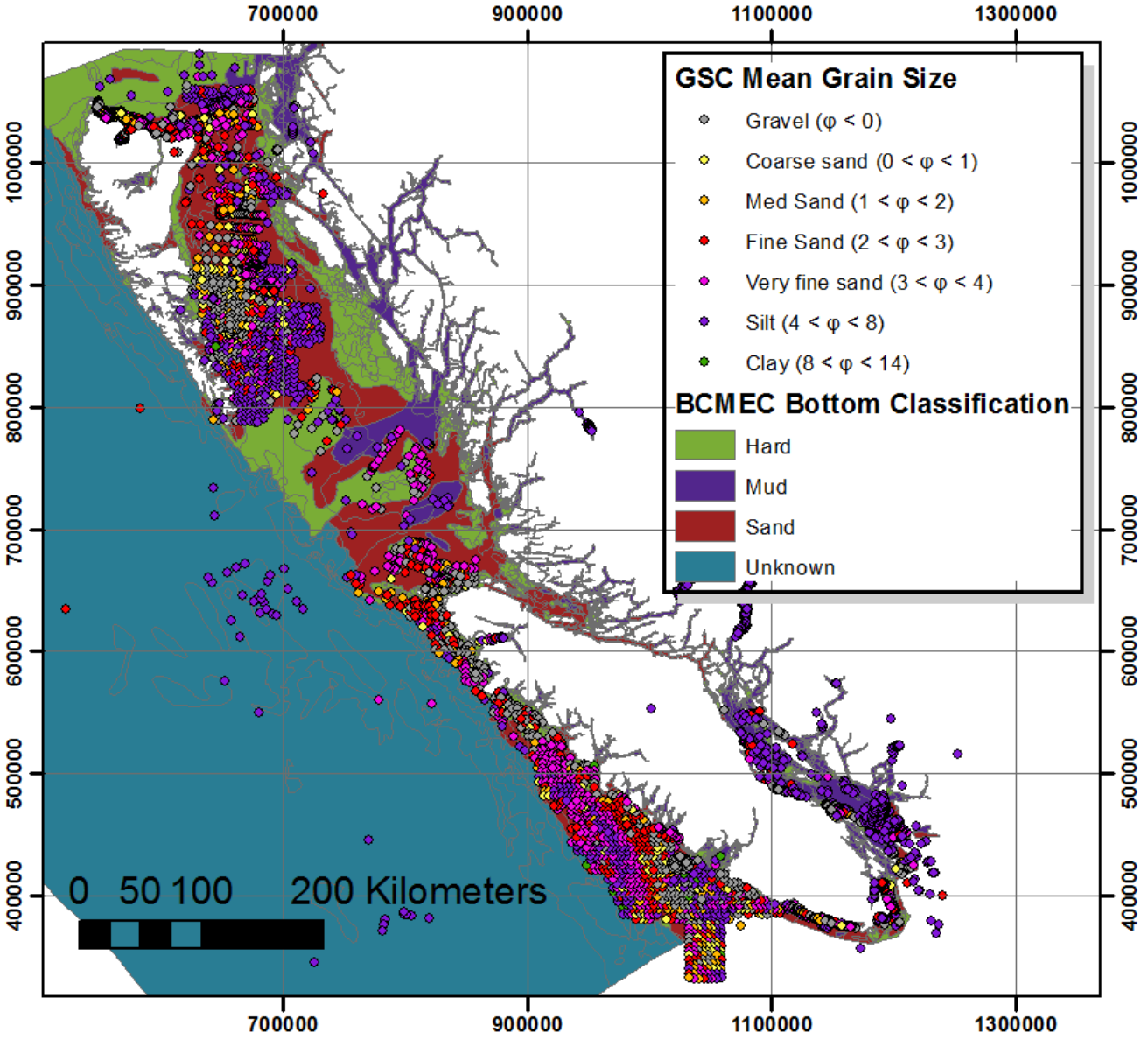


3. Characterise the Environment

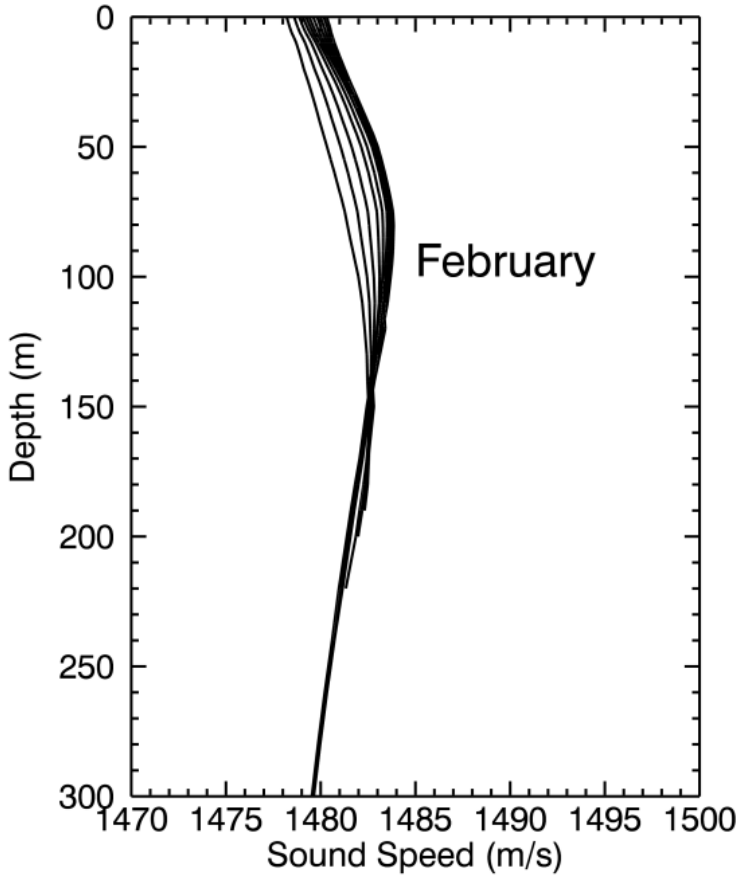


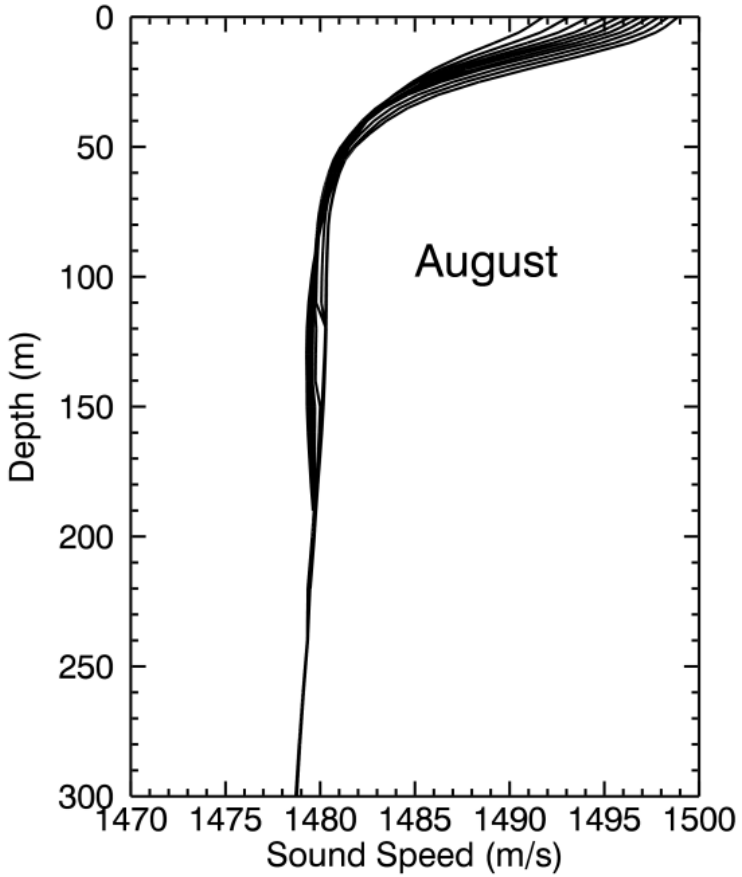
Bathymetry

Geoacoustics



Hydroacoustics





Mild surface duct
=> Little seafloor interaction

Downward refracting
=> Strong seafloor interaction

4. Cumulative Energy Model

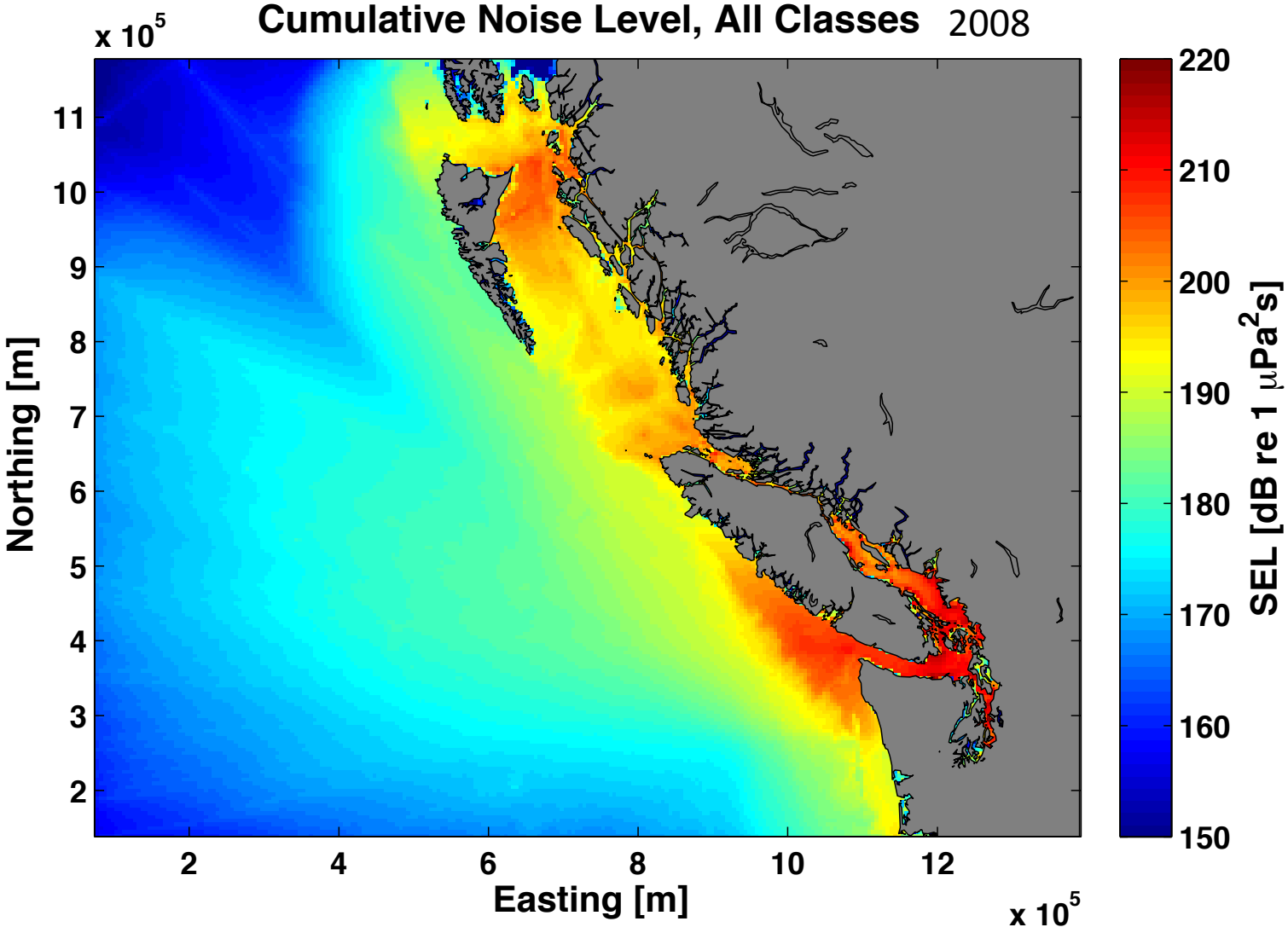
- Create source-receiver pairs < 100 km
- Model transmission loss (*TL*): geometrical spreading & absorption

$$TL = 20\log_{10} D_{\max} + 10\log_{10}\frac{R}{D_{\max}} + TL_a$$

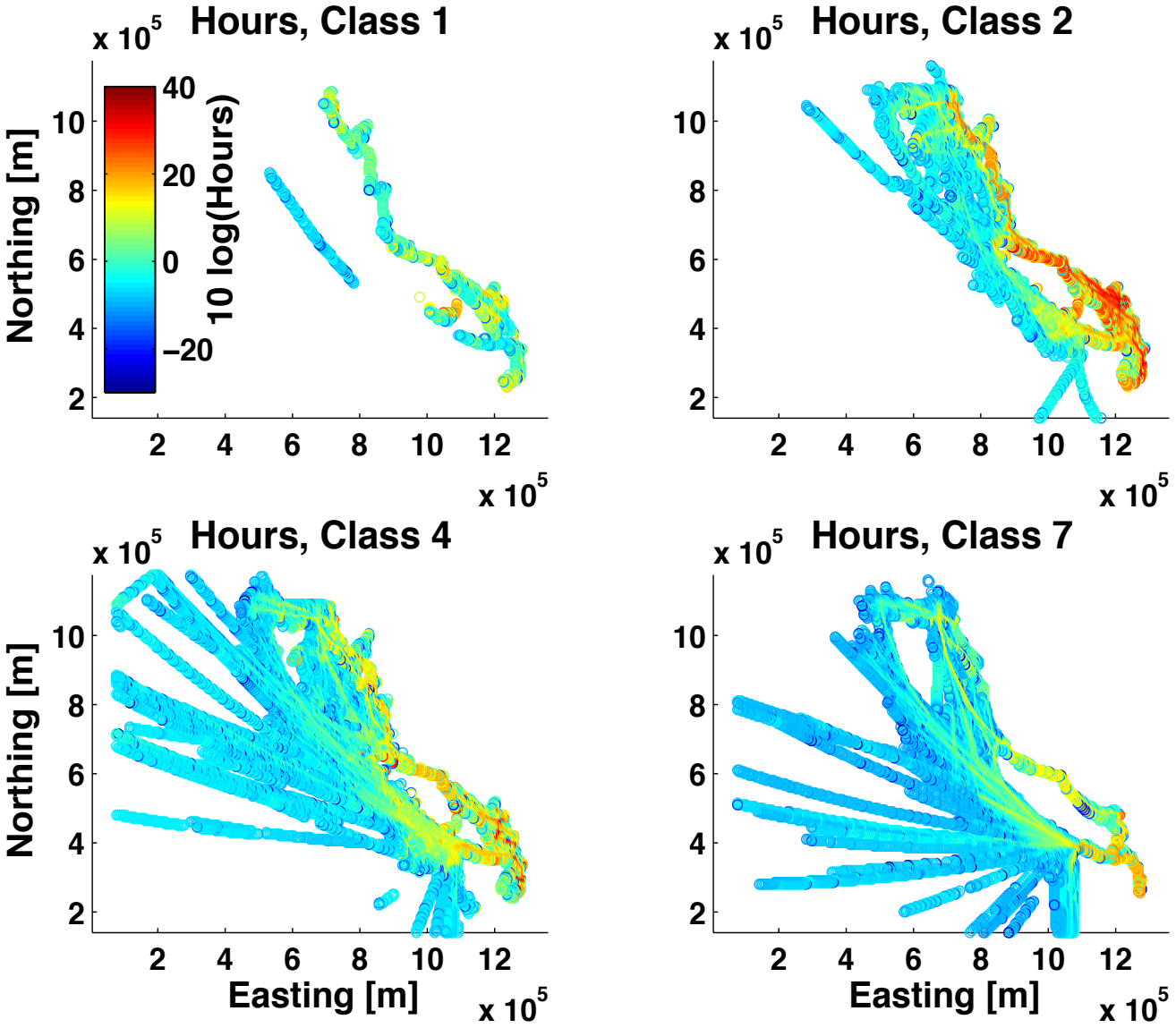
- Waveguide cut-off at wavelengths > 4 x *Dmin*
- Assign source spectra, apply *TL*
- Convert to sound exposure levels:

SEL = SPLrms + 10 log H

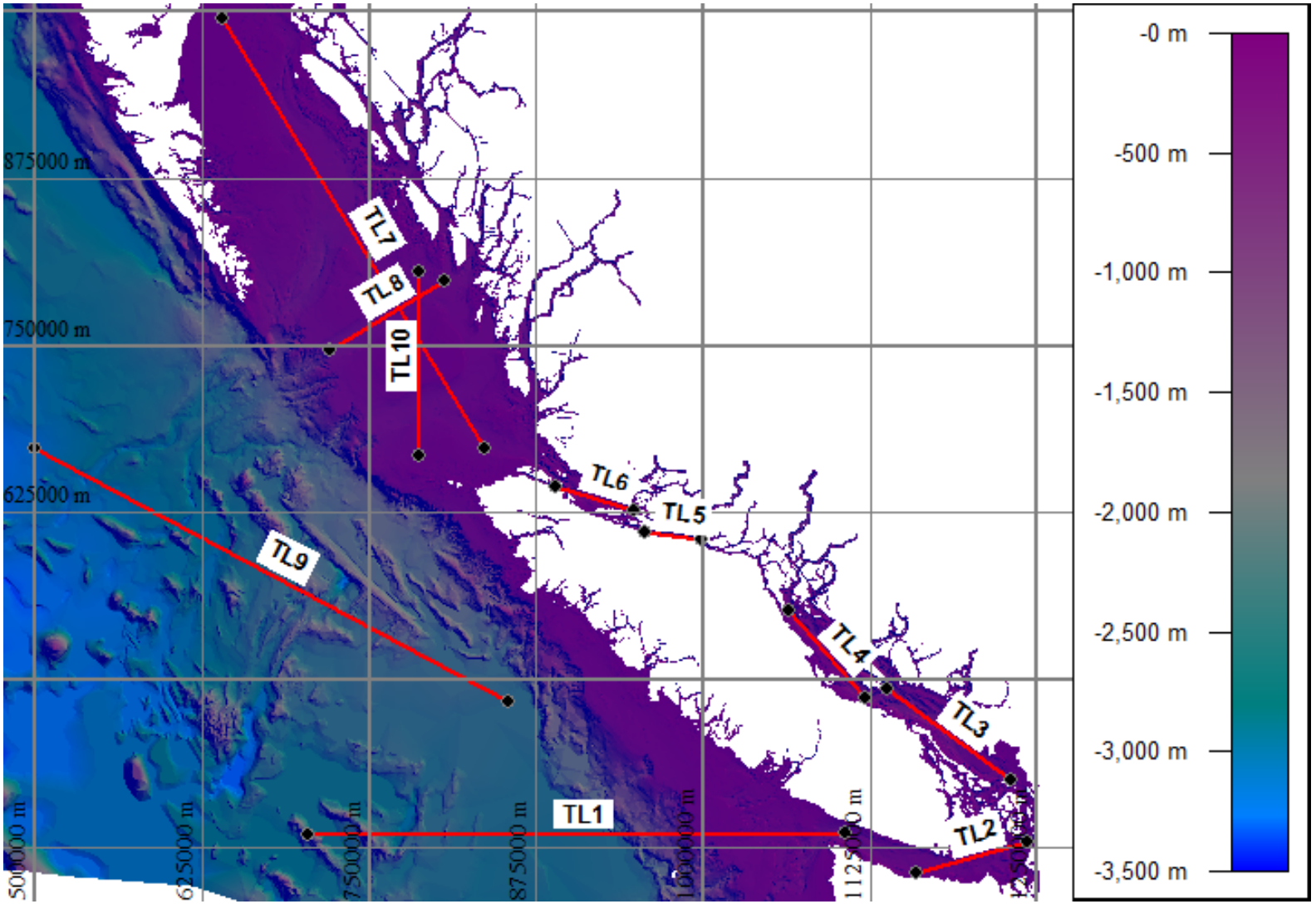
5. Results


Cumulative Noise Level, All Classes 2008
x 10^5
Northing [m]
11
10
9
8
7
6
5
4
3
2
2
4
6
8
10
12
Easting [m]
x 10^5
220
210
200
190
180
170
160
150
SEL [dB re 1 µPa^2s]

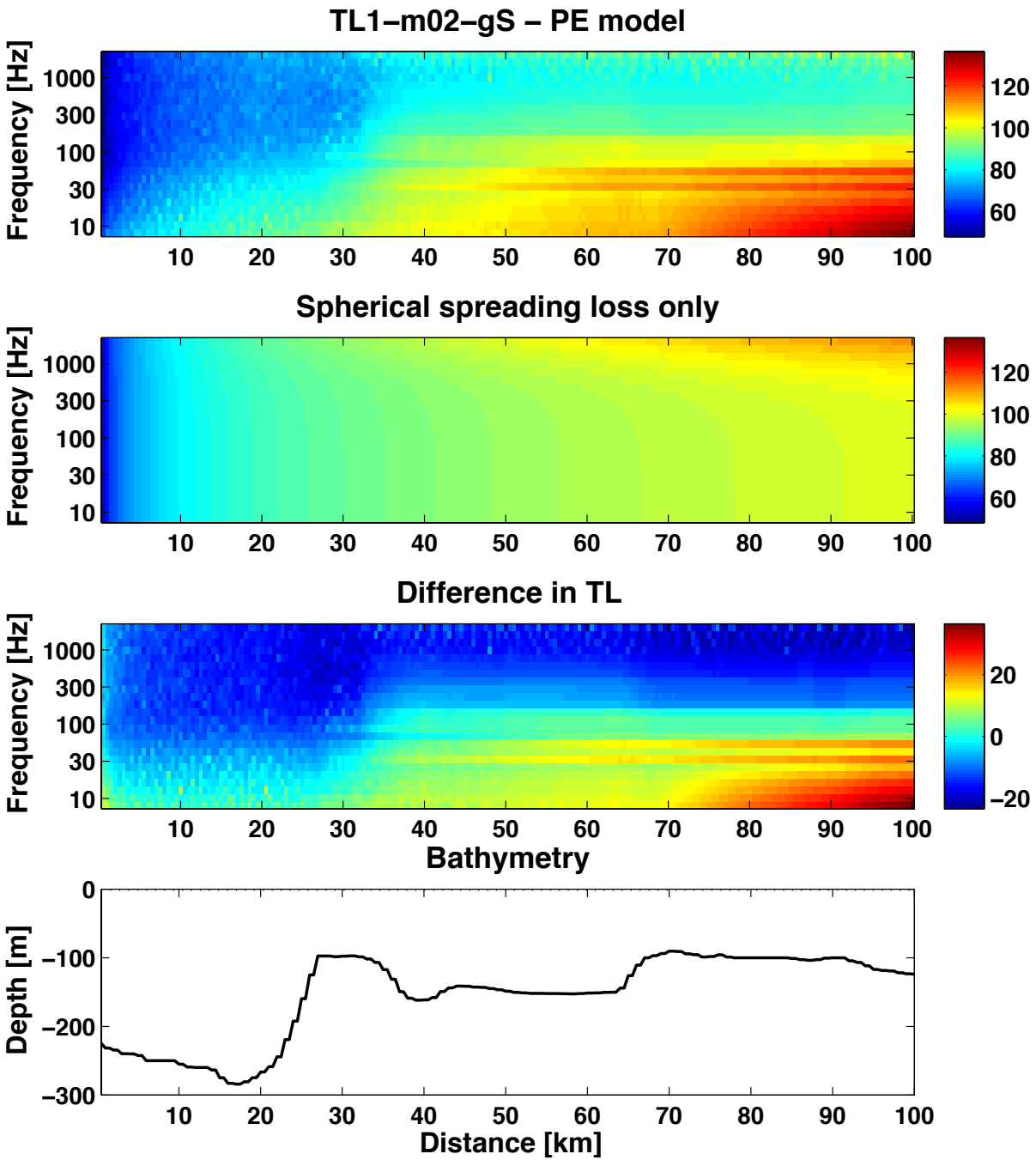
6. Error Analysis: *Shipping Data*



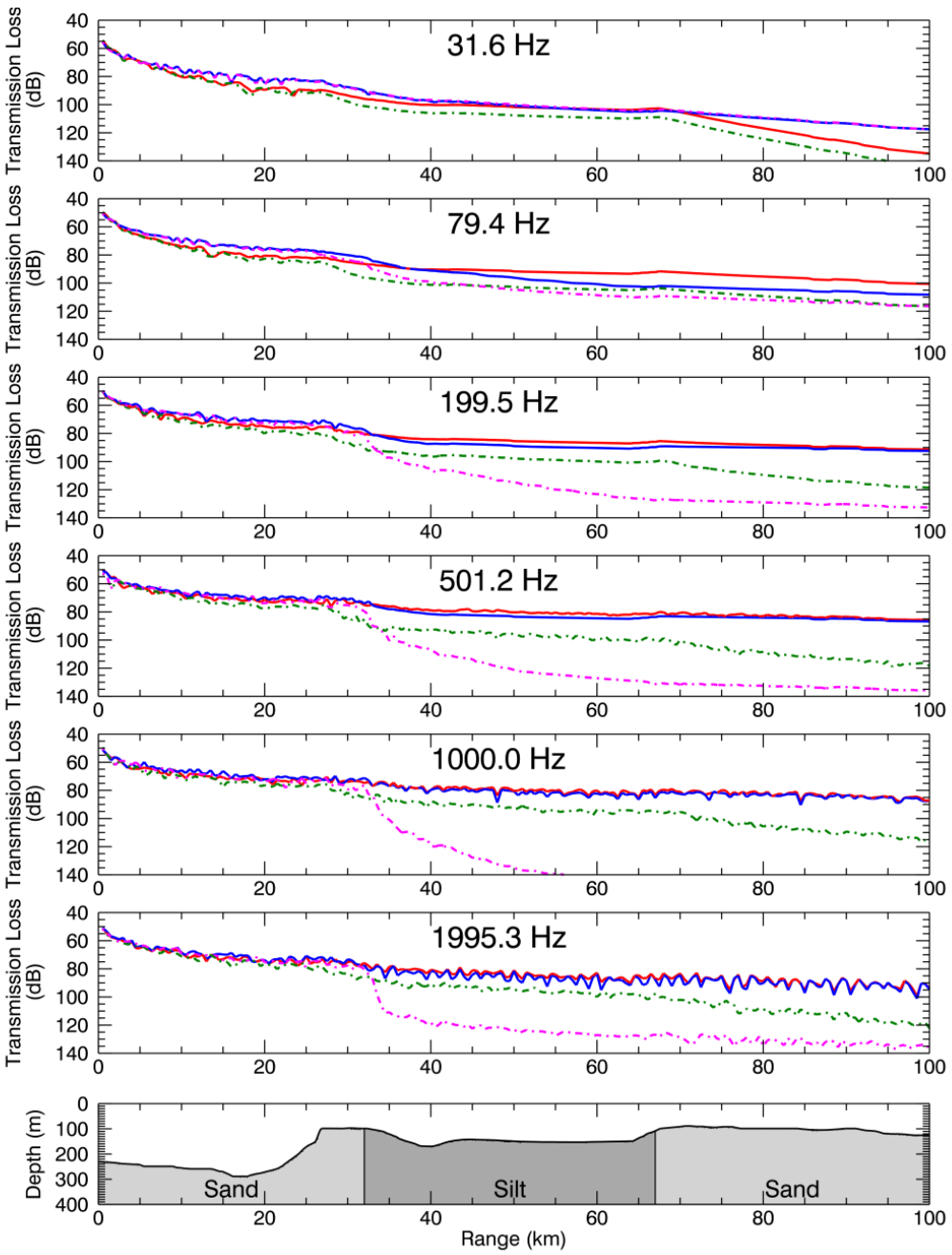
Error in Transmission Loss



Computed from 10 transects covering the different acoustic zones



Strong correlation of error with bathymetry



Correlation with geology

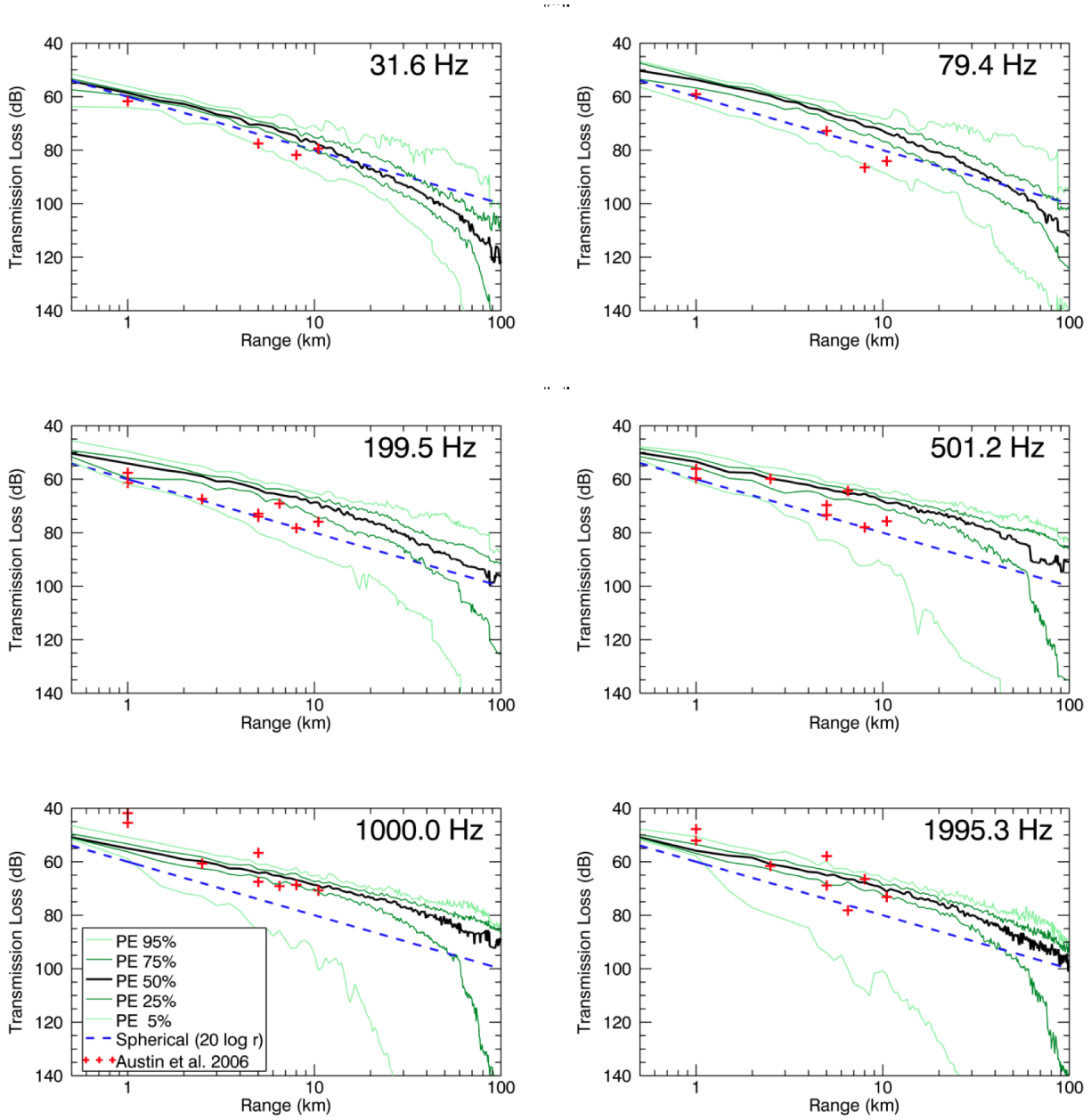
Seafloor interaction important during summer (downward refracting hydroacoustics)

Comparison of Transmission Loss:

Parabolic Equation

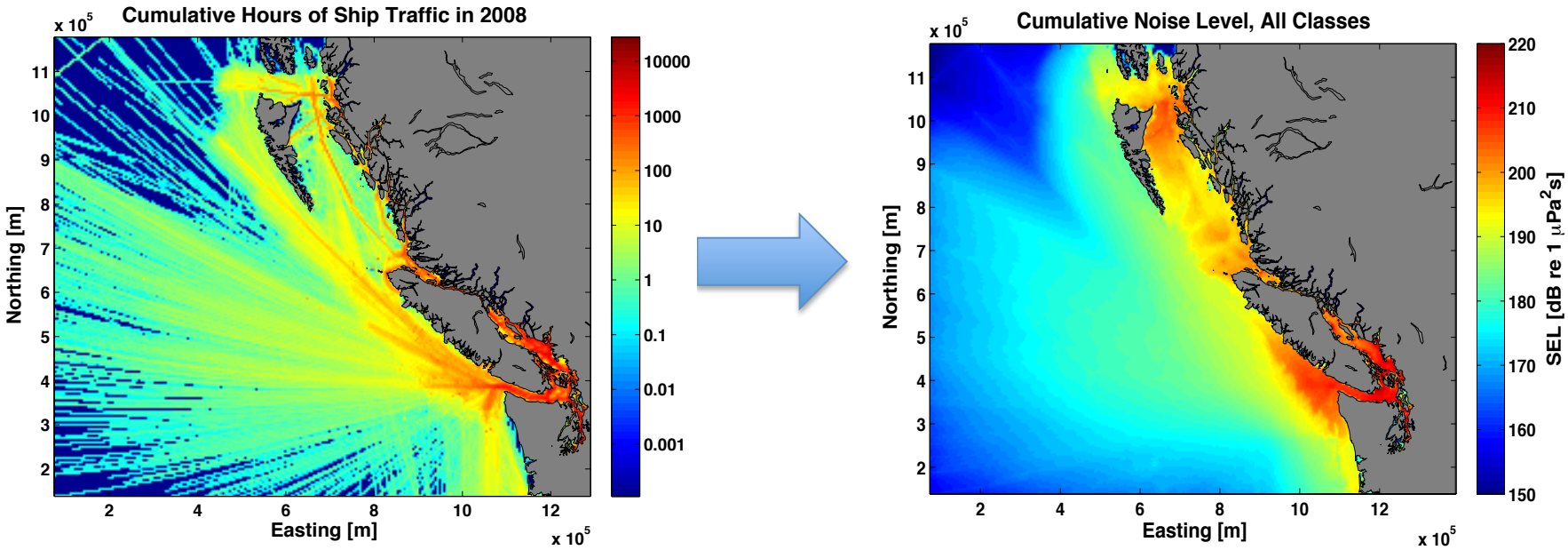
Vs.

Geometric Spreading

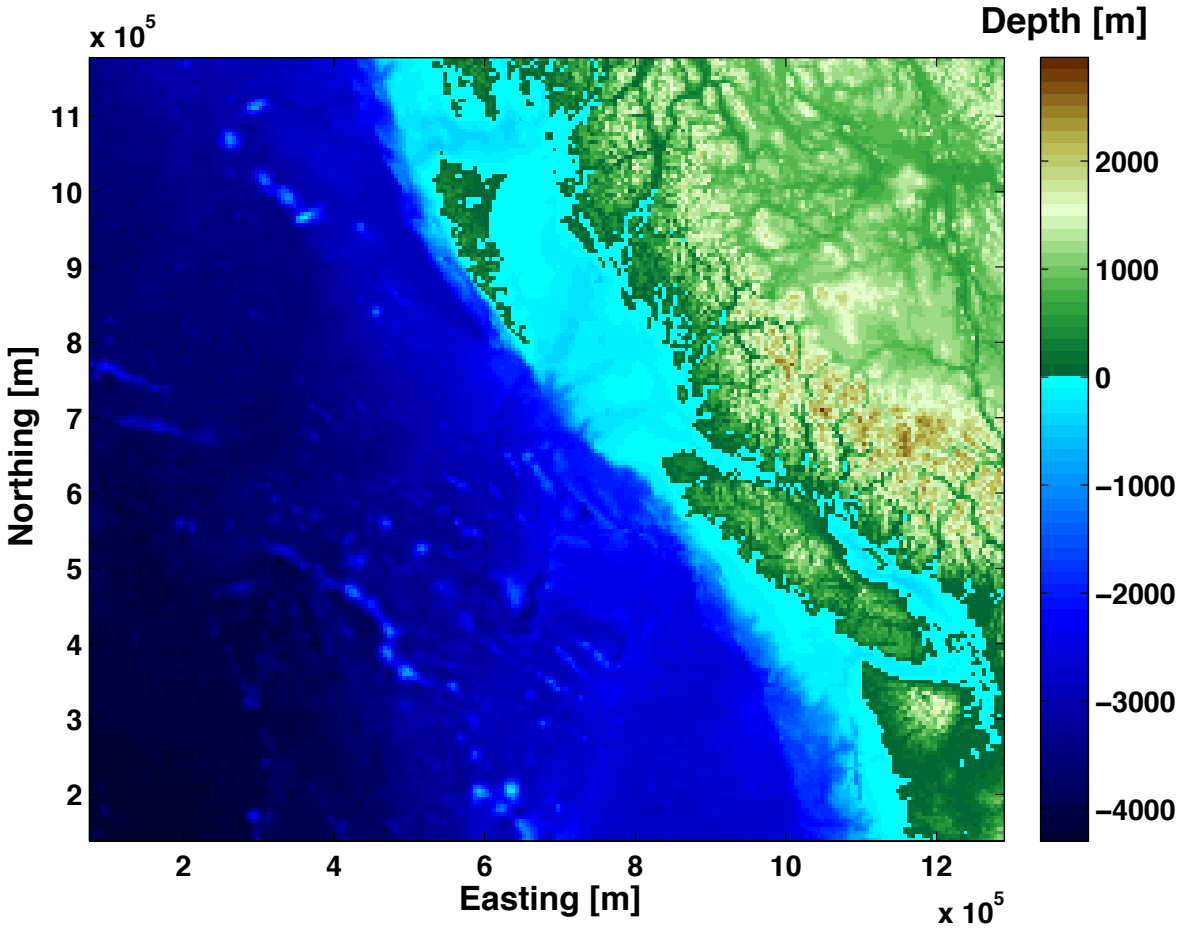


Green lines are percentile statistics of TL over all modelled transects, seafloor types and seasons.

7. What's Next?

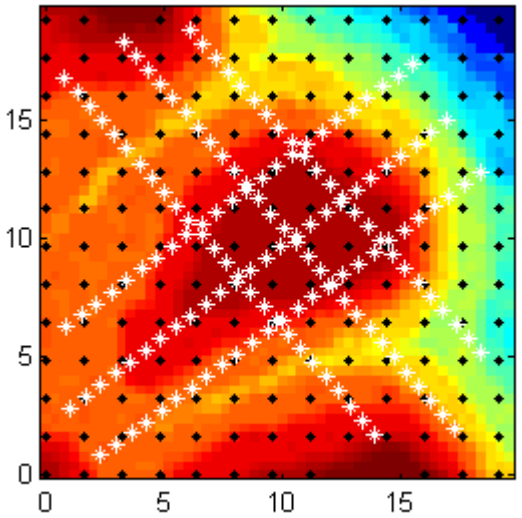

Cumulative Hours of Ship Traffic in 2008
x 10^5
Northing [m]
Easting [m]
x 10^5
10000
1000
100
10
1
0.1
0.01
0.001
Cumulative Noise Level, All Classes
x 10^5
Northing [m]
Easting [m]
x 10^5
SEL [dB re 1 μPa^2s]
220
210
200
190
180
170
160
150

Model on a Finer Geo. Scale

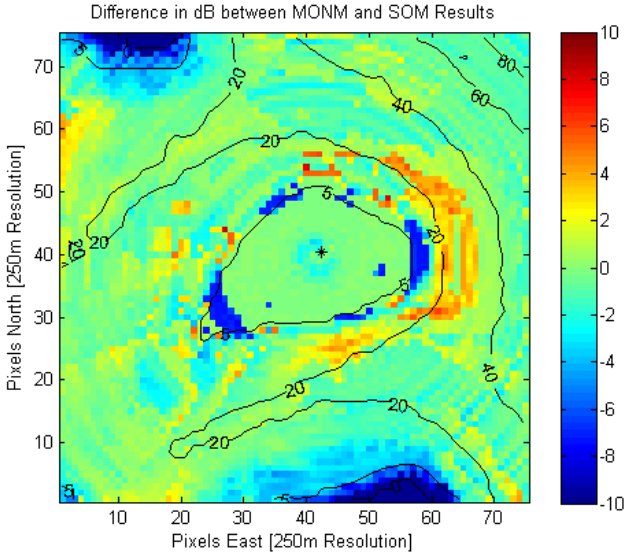


Where are the critical habitats?

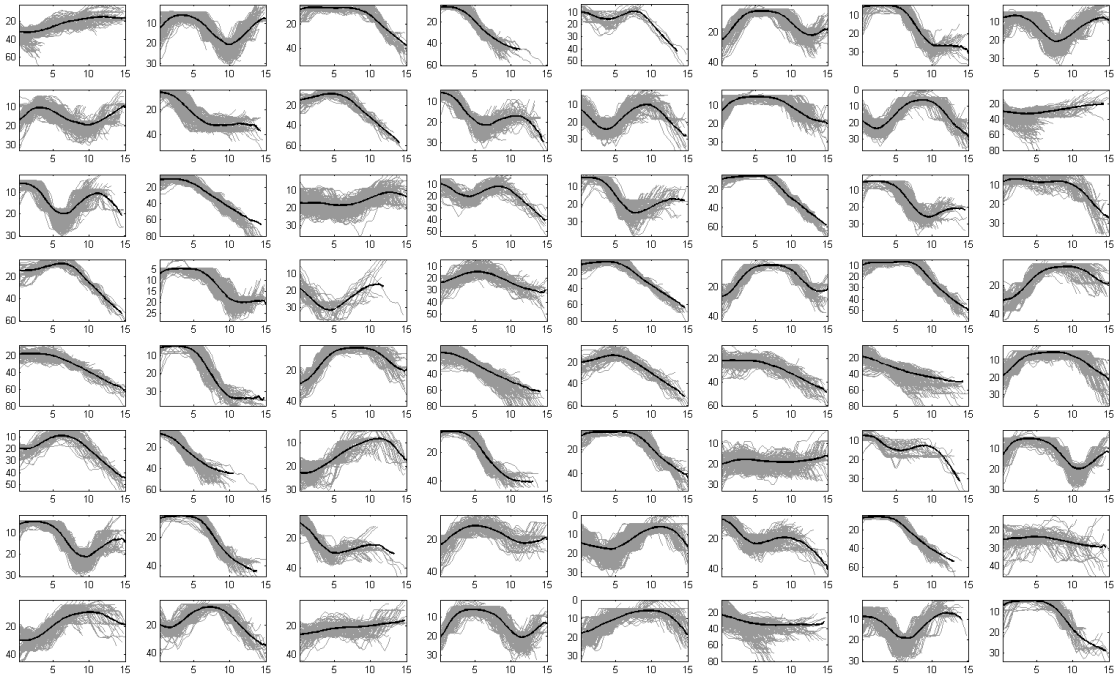
Source-receiver grid



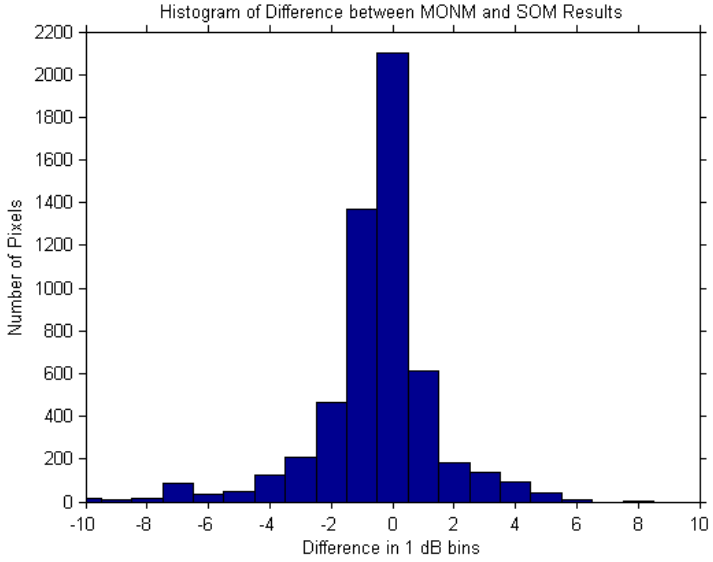
Use more sophisticated sound propagation model for fine-scale modelling (Erbe & King, JASA 2009)



Bathymetry clusters



Error in transmission loss



Create a Noise Layer for other Sources?

8. Remaining Questions

- What are the biological effects of noise exposure?
- How do these vary by species?
- How do the effects of noise interact with those of other stressors?
- How do we manage stressors / habitats

Thank You !

We gratefully acknowledge the support of WWF-Canada.
The results and recommendations presented do not necessarily represent the official position of WWF-Canada.