Large scale density estimation of blue and fin whales: combined distribution and density estimates using bearing data.

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Large Scale Density Estimation Project

- **ONR funded project**

- **Goal**: develop new density estimation method using bearing information from sparse arrays

- **Will:**

  (a) be effective over large spatial scales.

  (b) be designed to cope with spatial variation in animal density

  (c) utilize sparse array data.

- **Target species**: developed for blue and fin whales but will be directly applicable to other species
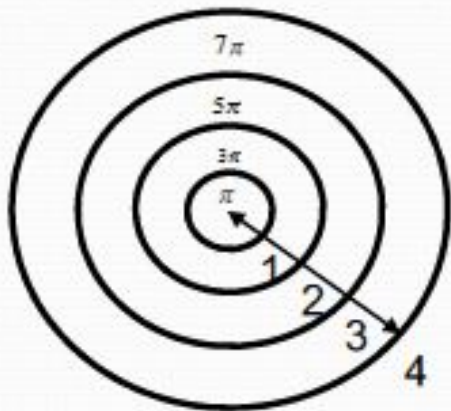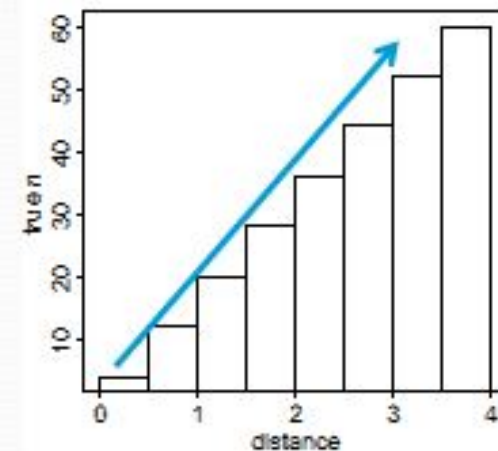
Density estimation: animal distribution

- Key assumptions of standard density estimation methods - **on average**, animal distribution with respect to the monitoring lines is uniform.
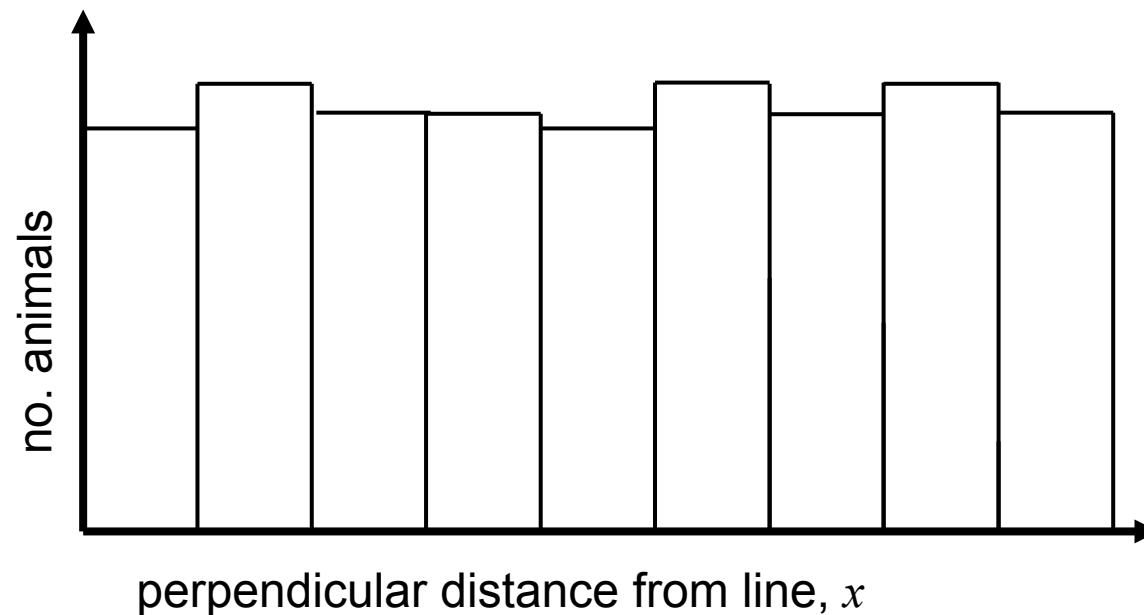
no. animals

perpendicular distance from line, x

Density estimation: animal distribution

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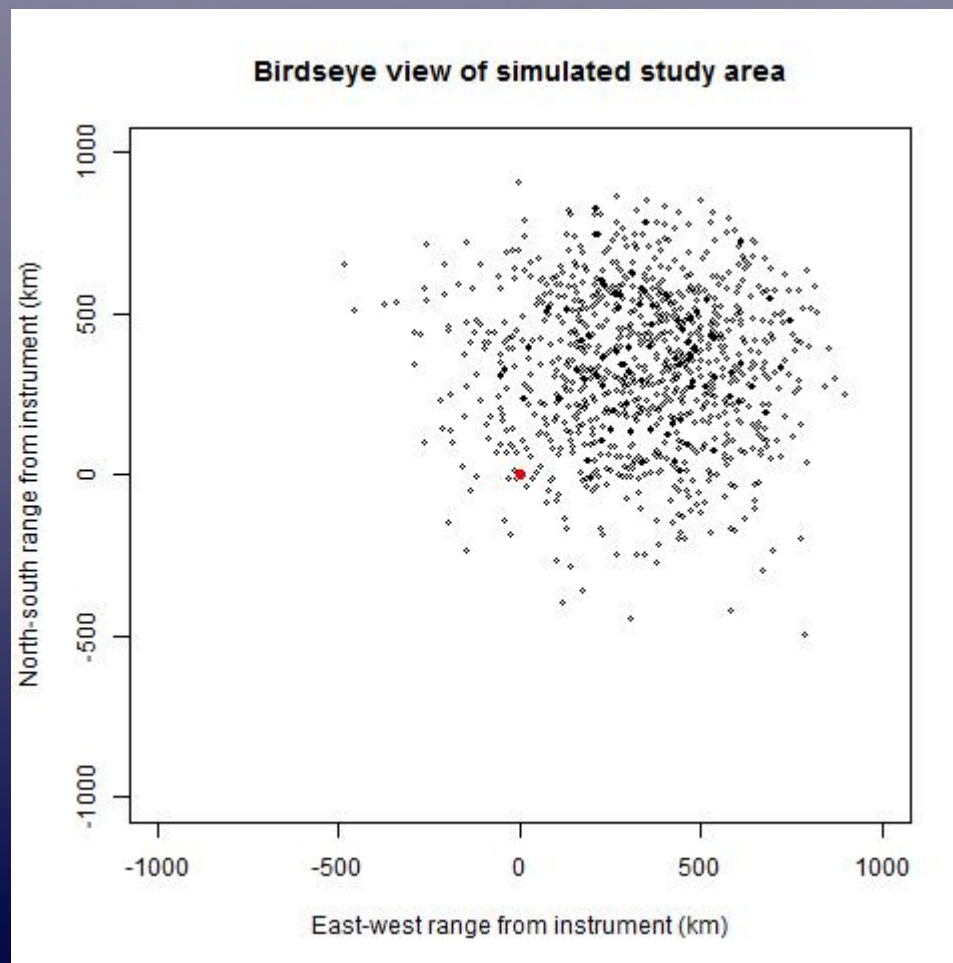
Density estimation: animal distribution

- With **many** monitoring lines/points, assumption can be valid.

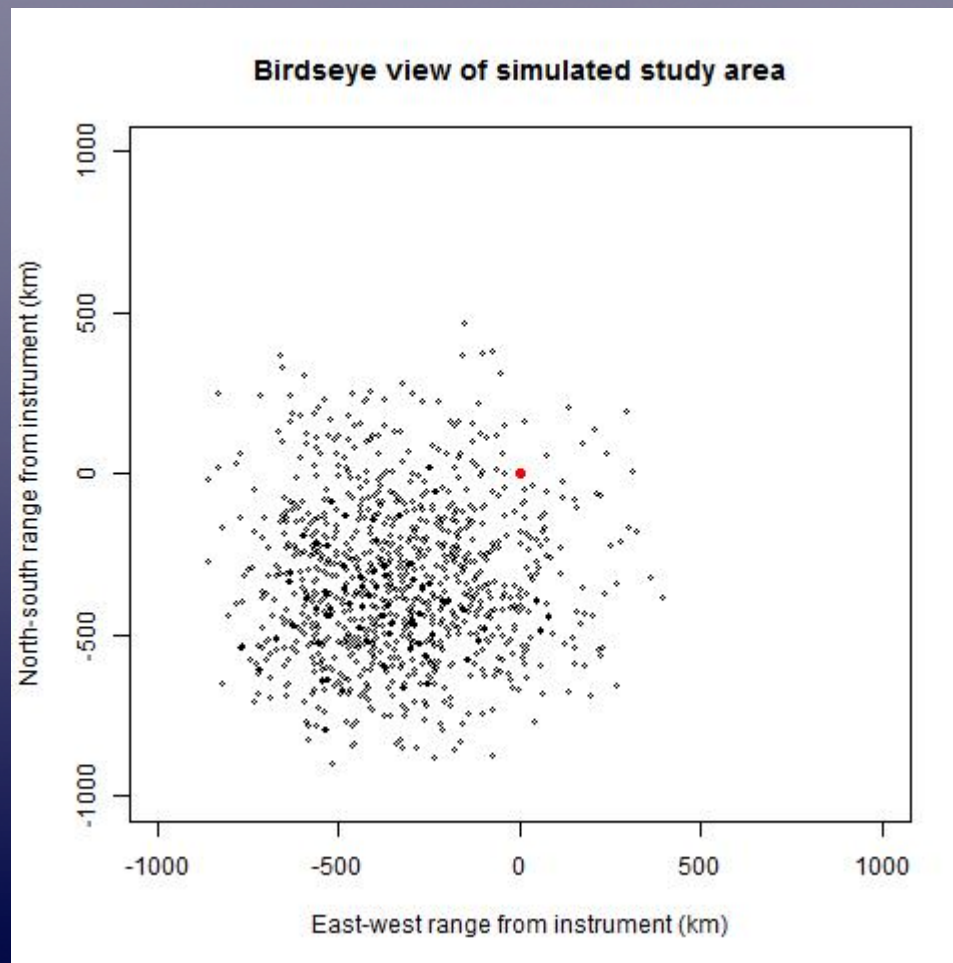Birdseye view of simulated study area

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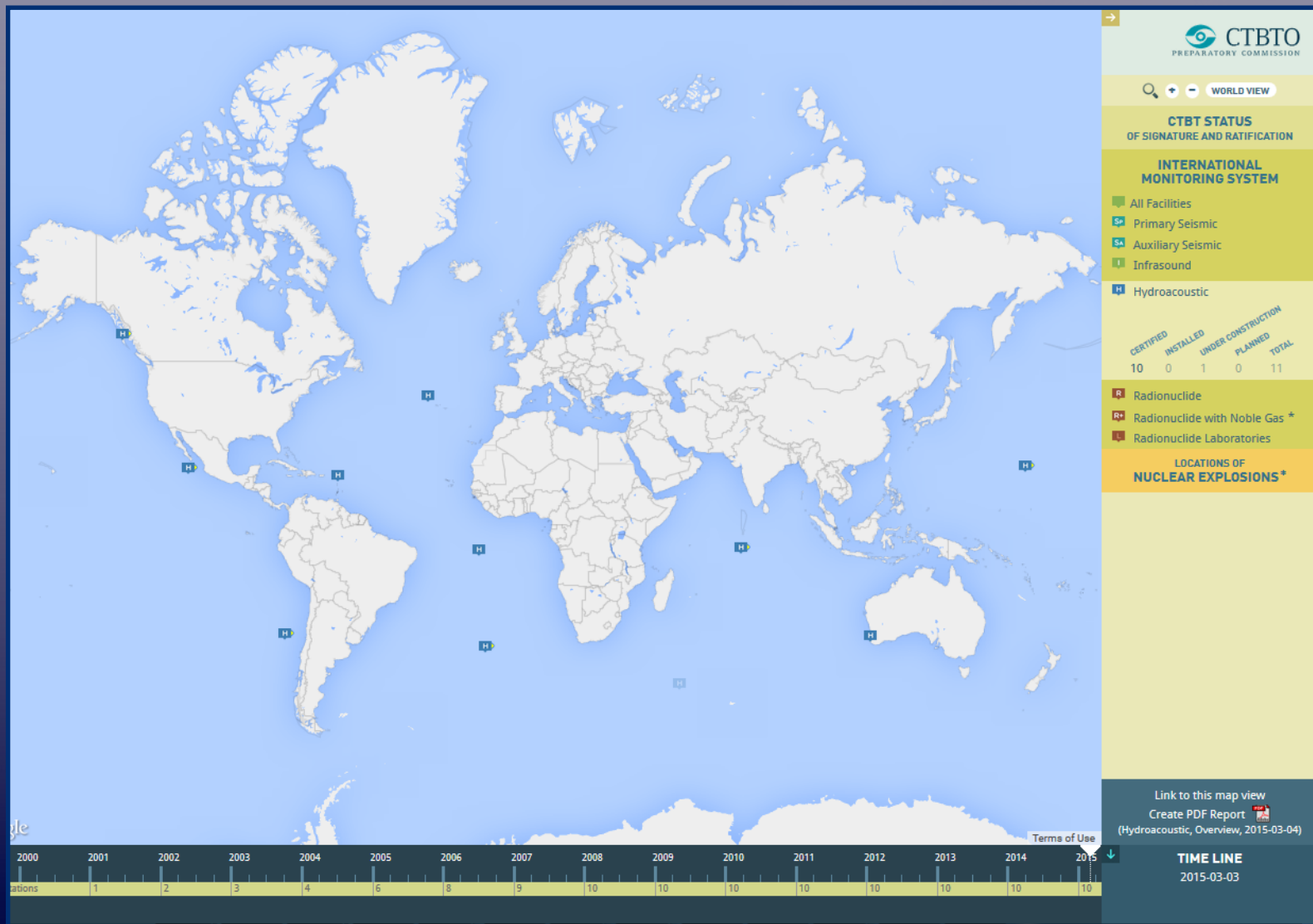

Birdseye view of simulated study area
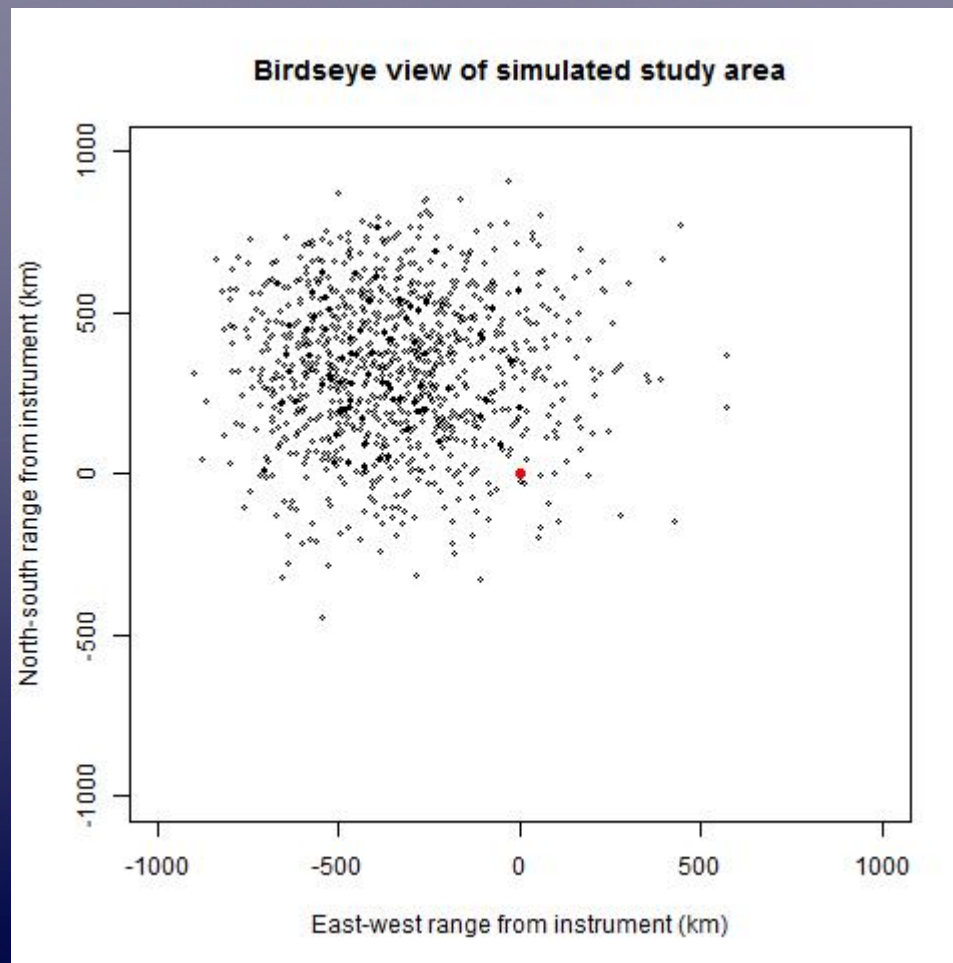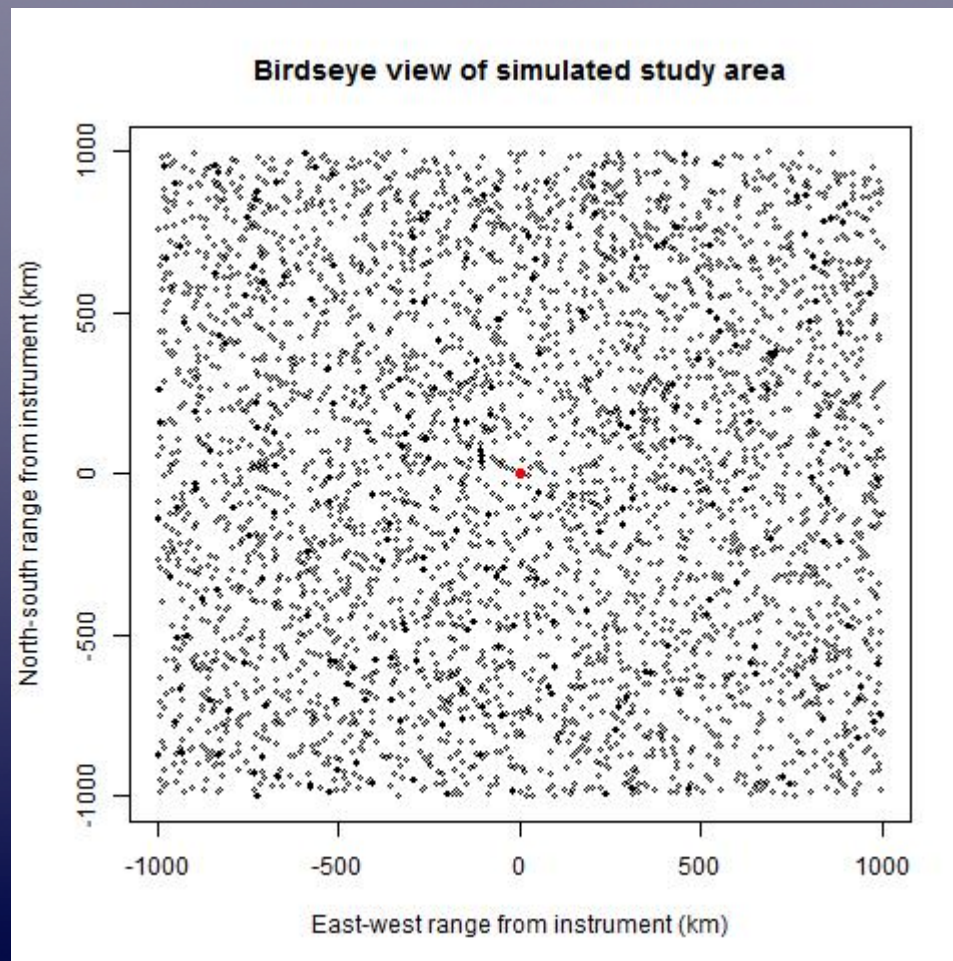
Density estimation: animal distribution

- With **few** monitoring lines/points, assumption likely to be violated.
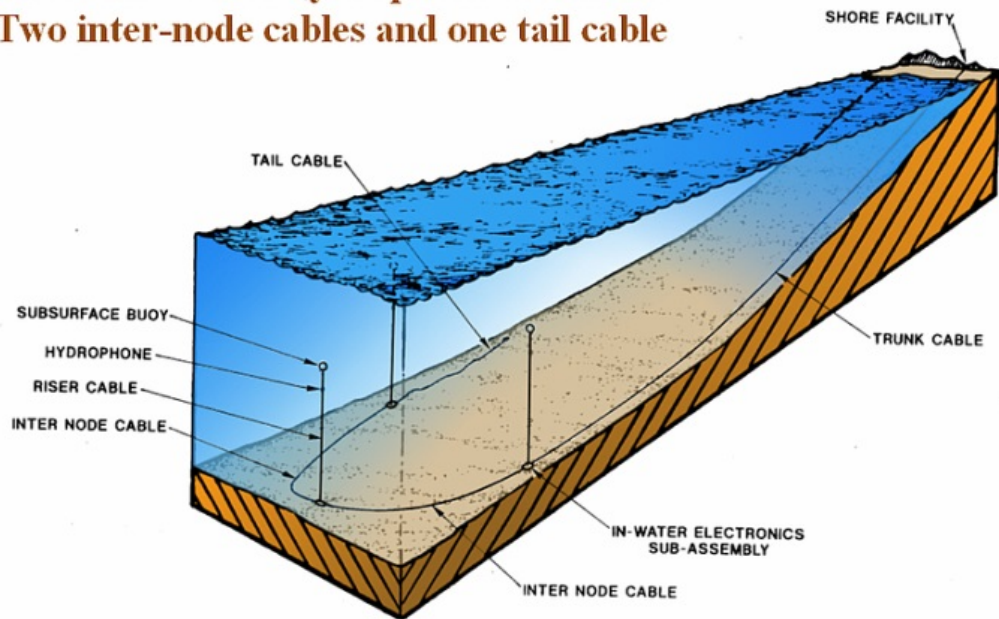- This is the case for sparse arrays – particularly if monitoring a large area.

Birdseye view of simulated study area
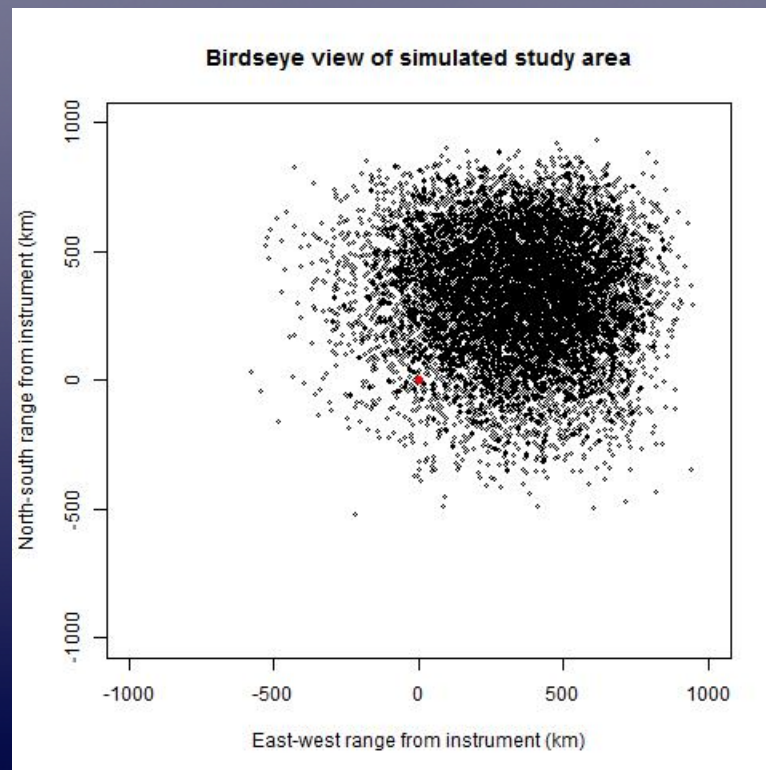
Comprehensive Nuclear Test Ban Treaty Organisation : International Monitoring System
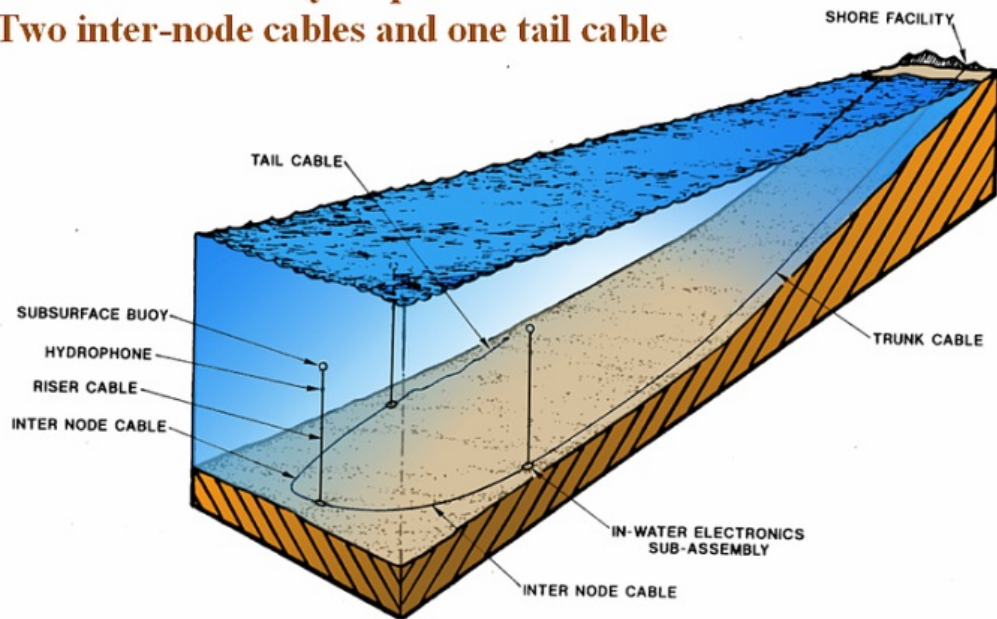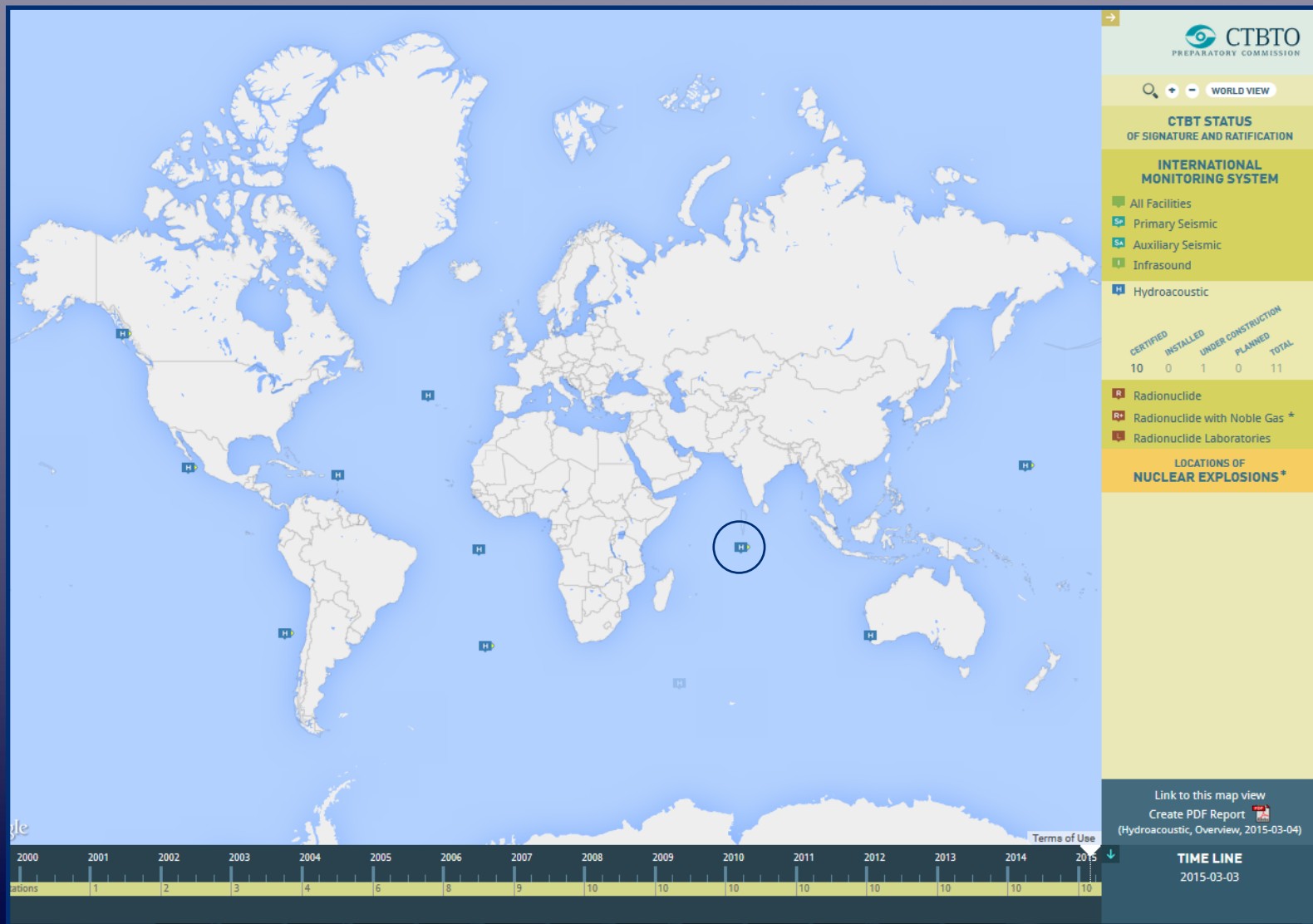
CTBTO Hydroacoustic Instruments

Trunk cable deployed from shore
Three anchor/electronics nodes
Three mid-water hydrophone assemblies
Two inter-node cables and one tail cable

SHORE FACILITY

TAIL CABLE

SUBSURFACE BUOY
HYDROPHONE
RISER CABLE
INTER NODE CABLE

TRUNK CABLE

IN-WATER ELECTRONICS SUB-ASSEMBLY

INTER NODE CABLE

From 'CTBTO Public Information, http://www.ctbto.org/

CTBTO Hydroacoustic Instruments

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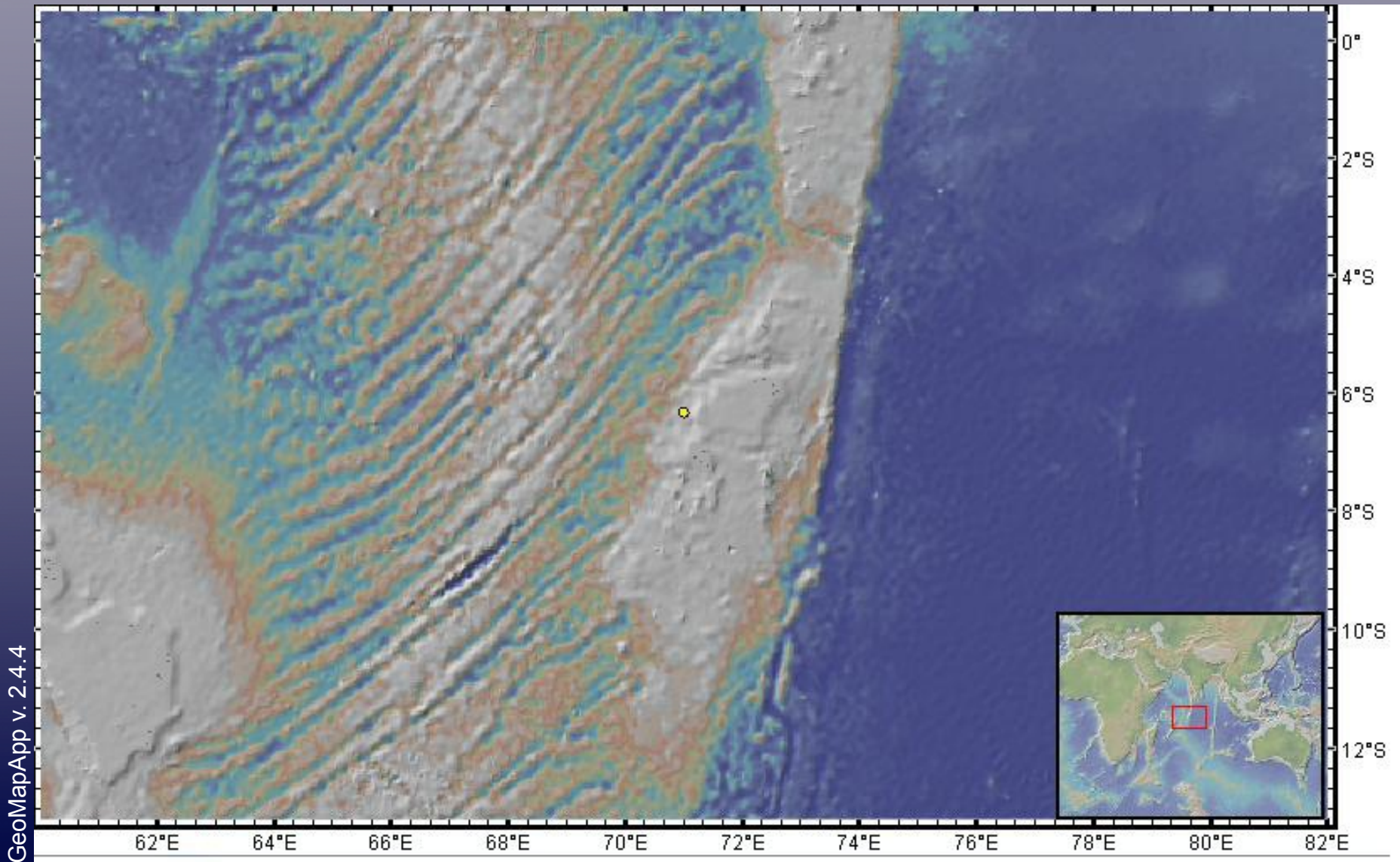Two inter-node cables and one tail cable

SHORE FACILITY
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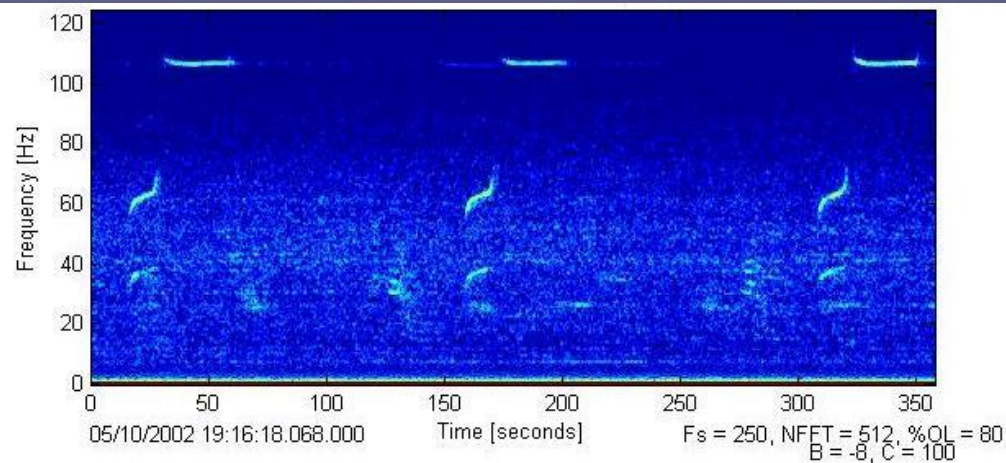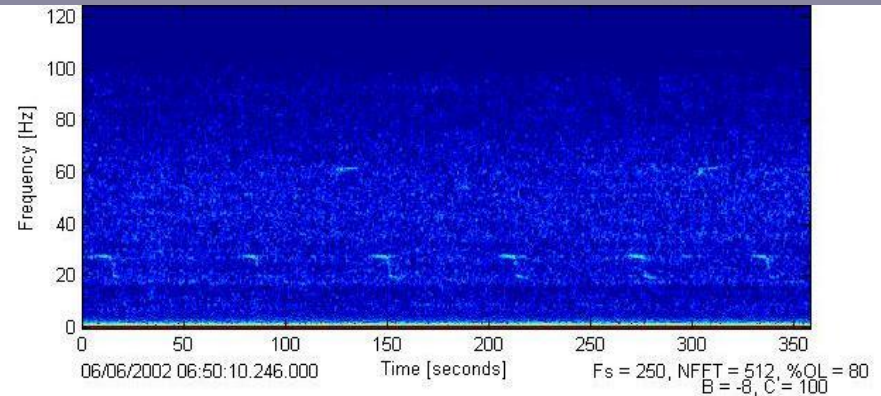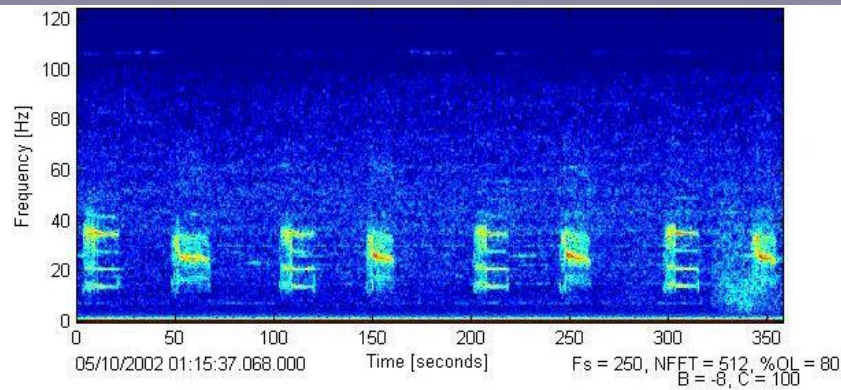INTER NODE CABLE

Comprehensive Nuclear Test Ban Treaty Organisation: Diego Garcia

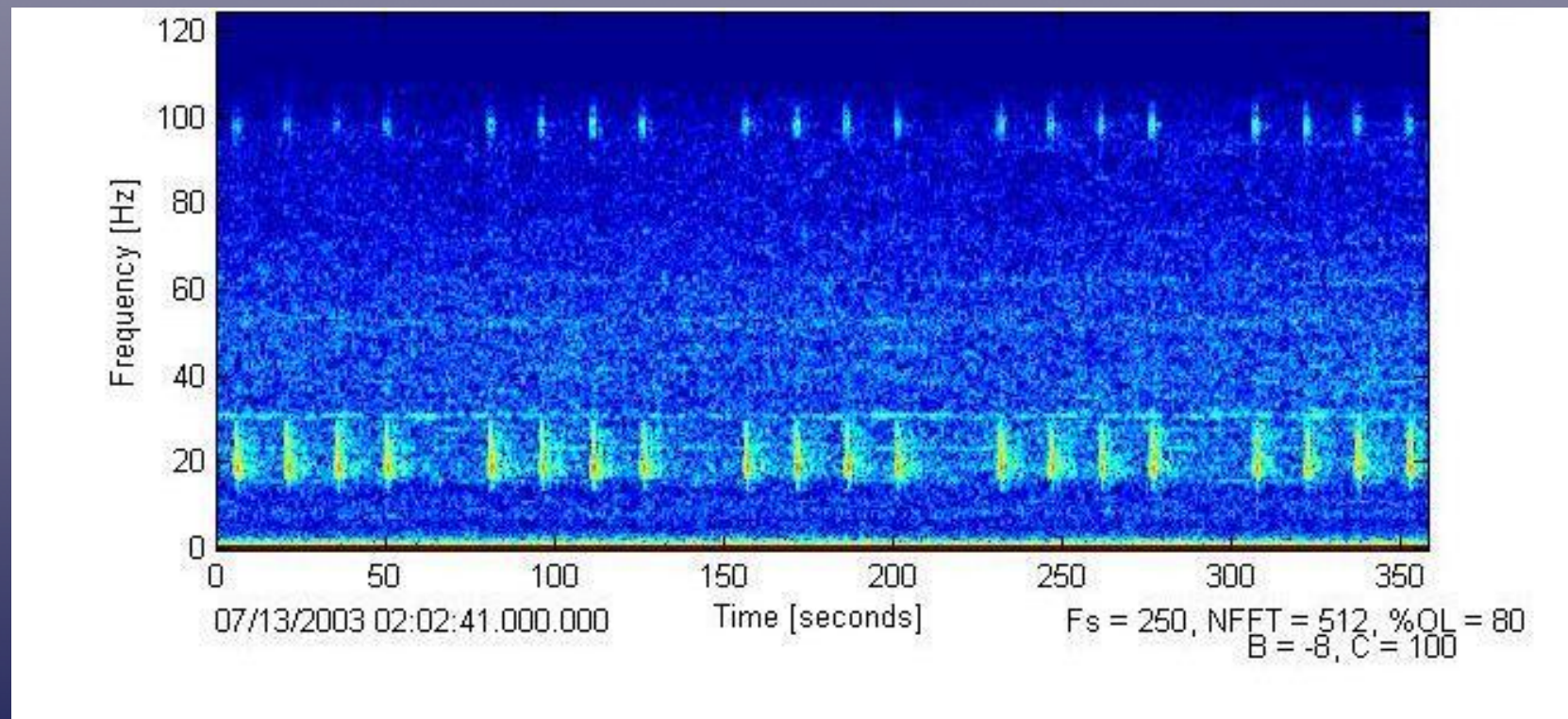# Comprehensive Nuclear Test Ban Treaty Organisation: Diego Garcia

GeoMapApp v. 2.4.4

Comprehensive Nuclear Test Ban Treaty Organisation: Diego Garcia

Comprehensive Nuclear Test Ban Treaty Organisation: Diego Garcia

Methods – what is needed?

- **For each detected call:**
  - Horizontal bearing to calls
  - Call signal to noise ratio

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Methods – what is needed?

- **For each detected call:**
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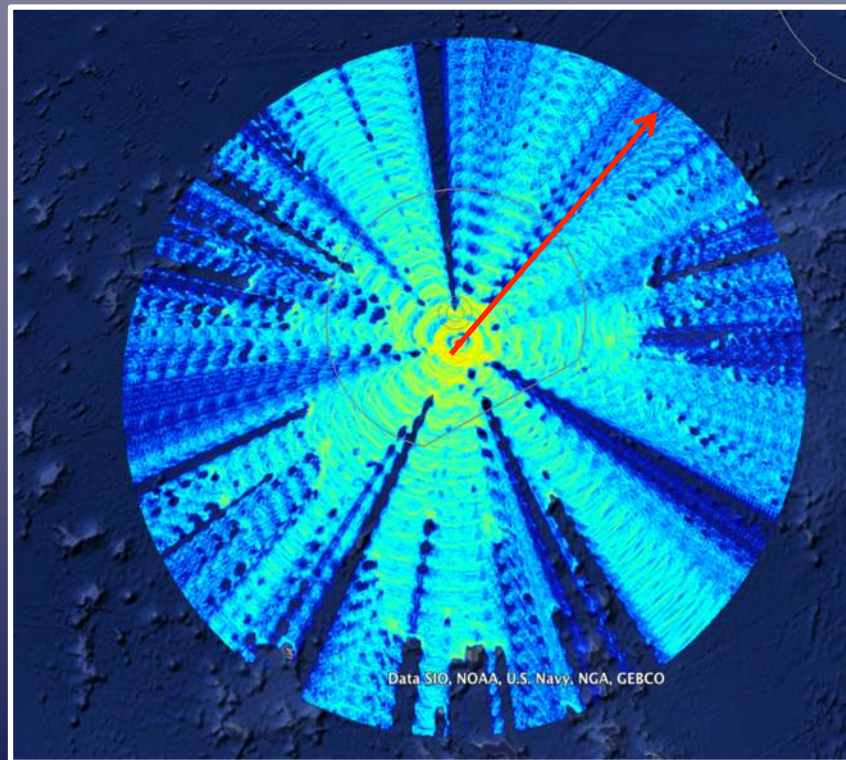 - Call signal to noise ratio

- **Data about calls:**
  - Source level information

- Characterised detector:
  - Linking detection probability to SNR

- Oceanography data:
  - Sound propagation
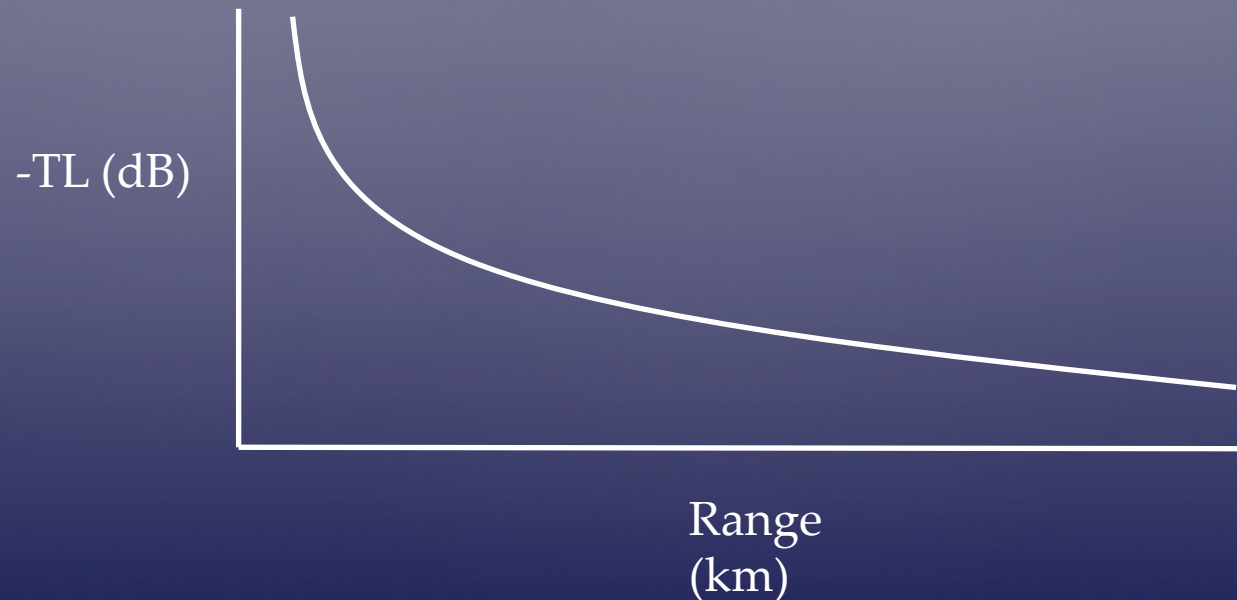 - Noise levels (for simulation)

Methods - overview

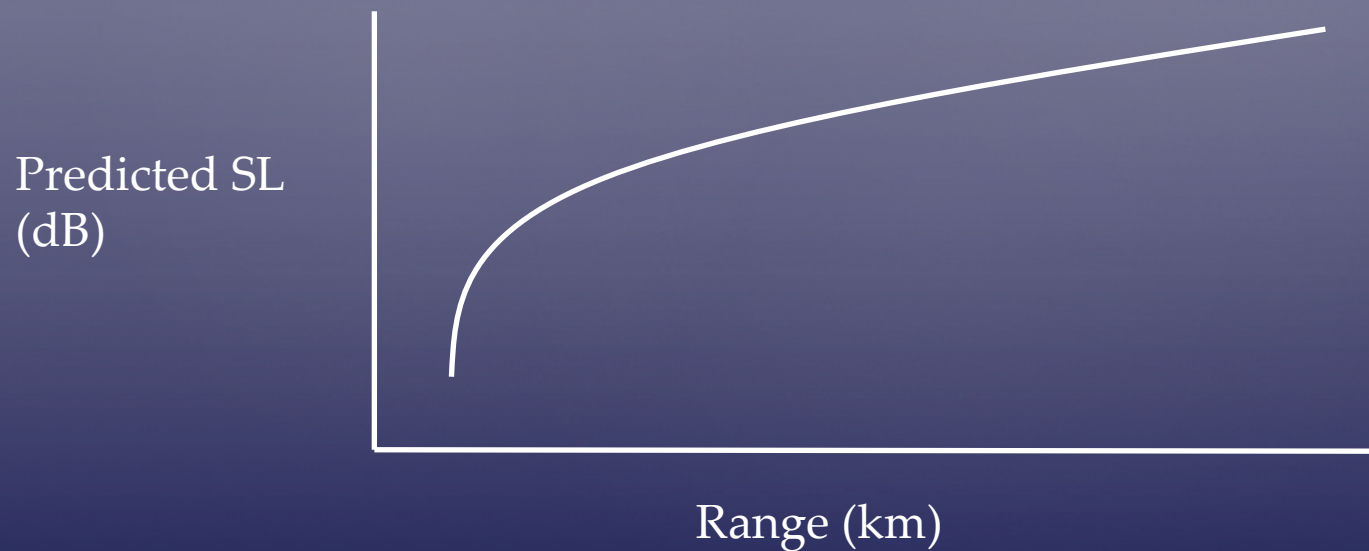- Use bearing to assign bearing-specific transmission loss (TL) data to call

Methods - overview

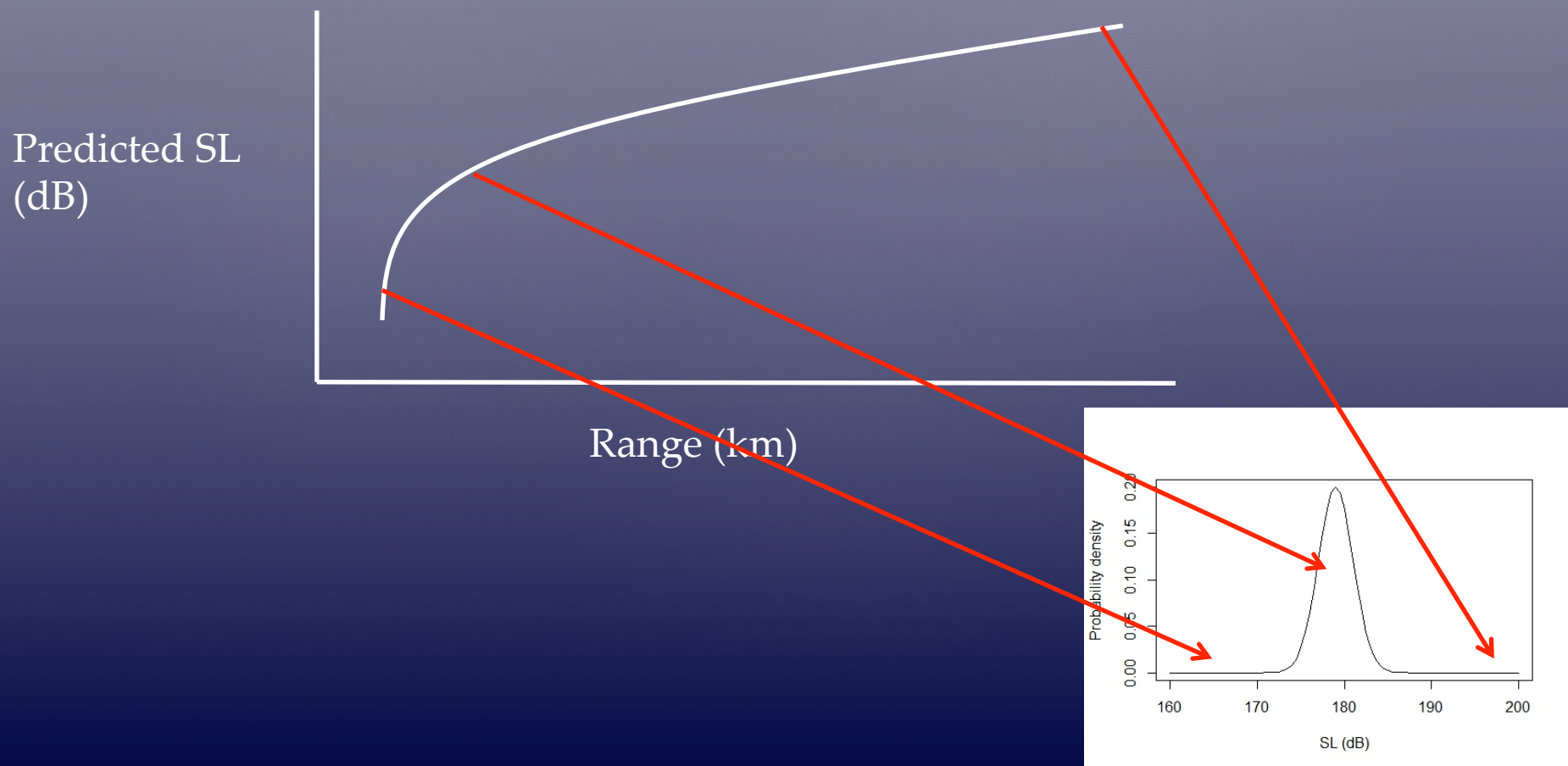- Use call received level (RL) and TL to estimate source level (SL) at each range step

-TL (dB)

Range (km)

Methods - overview

- Use call received level (RL) and TL to estimate source level (SL) at each range step

Predicted SL
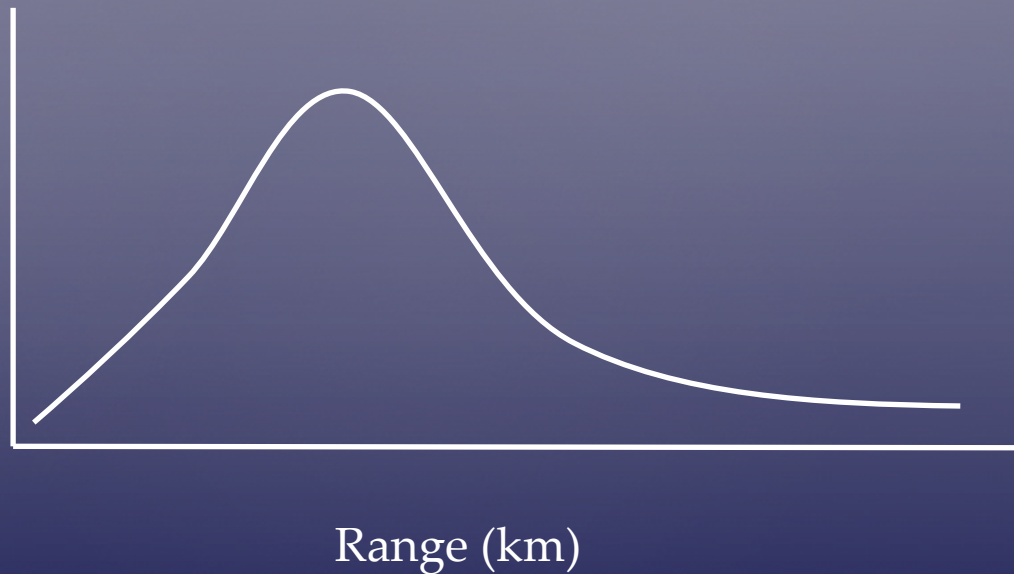(dB)

Range (km)

Methods - overview

- Assess the probability density of each predicted SL at each range using an assumed SL distribution.

Methods - overview

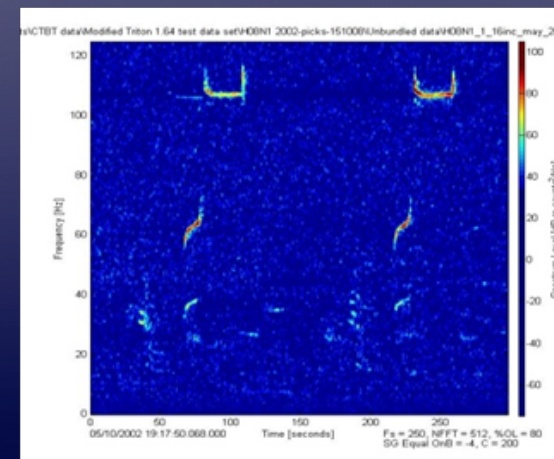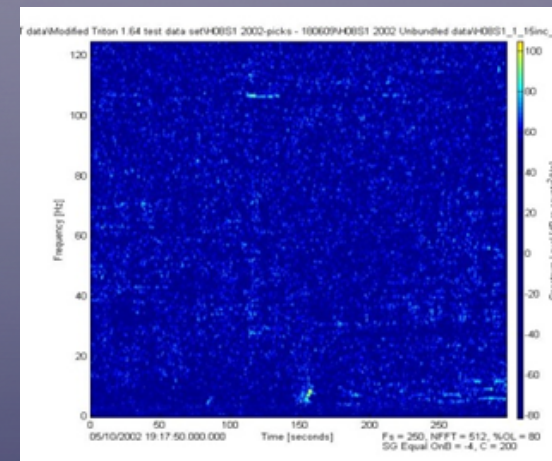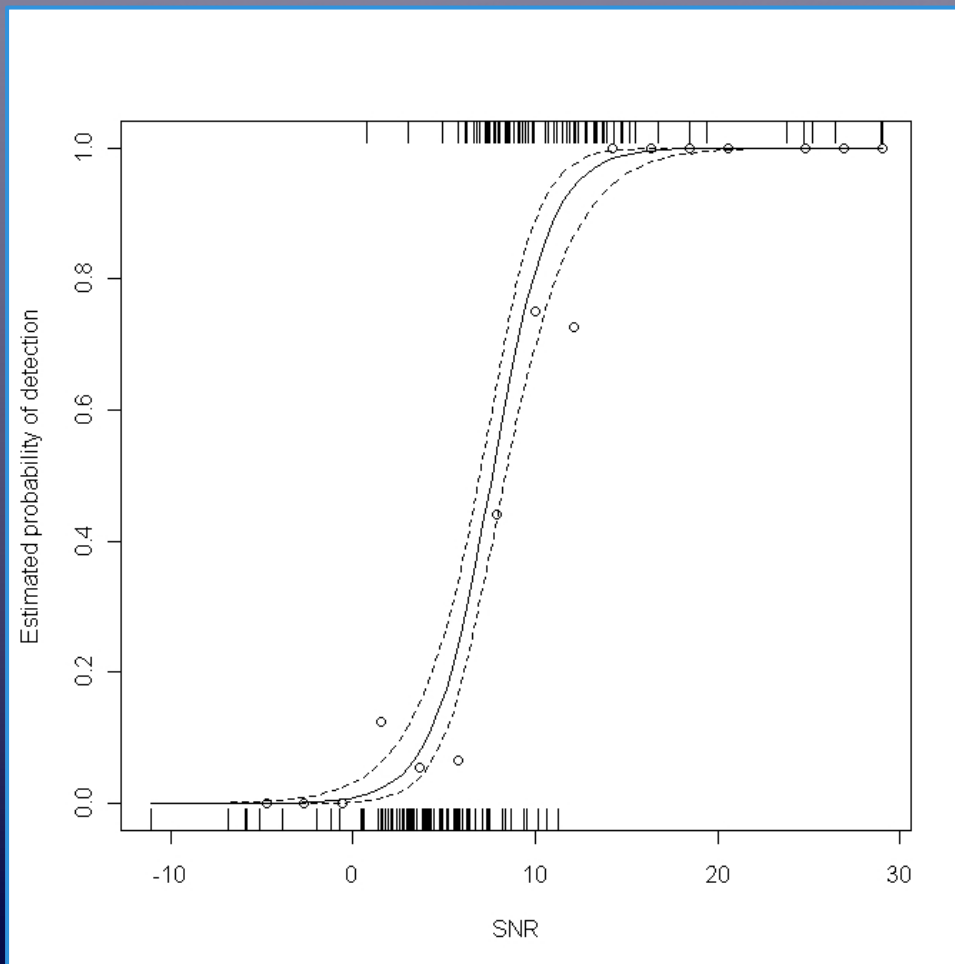- Split the call along the range according to the weighting from the SL pdf.

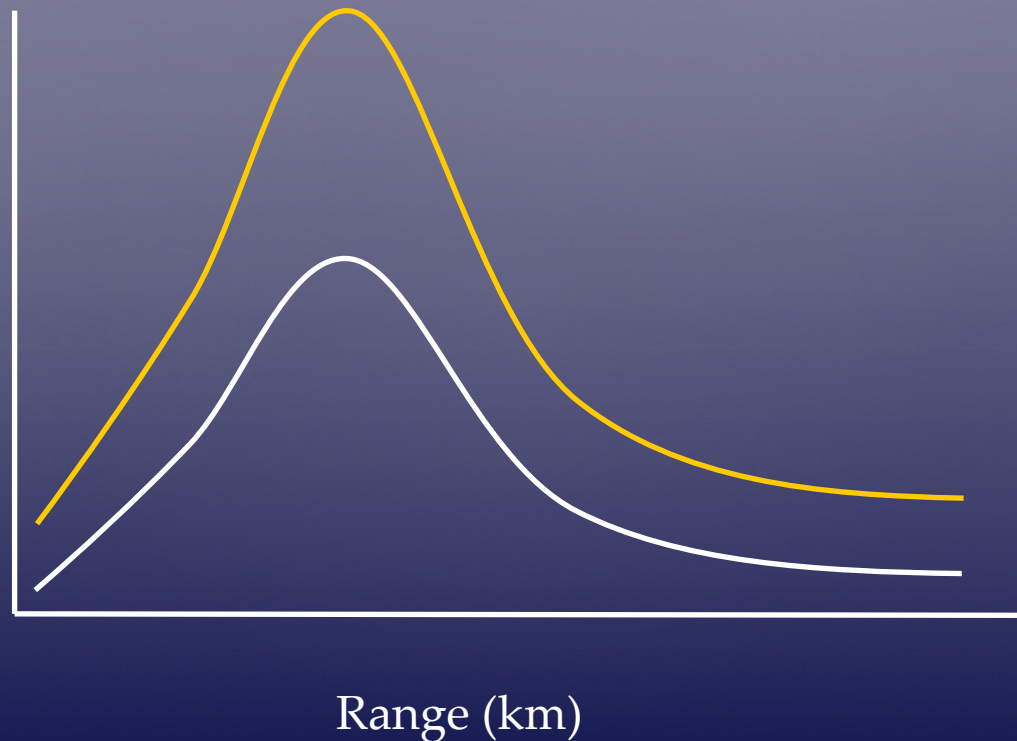Proportion of a single call

Range (km)

Methods - overview

- Correct the call for missed calls using relationship between signal to noise (SNR) and probability of detection.
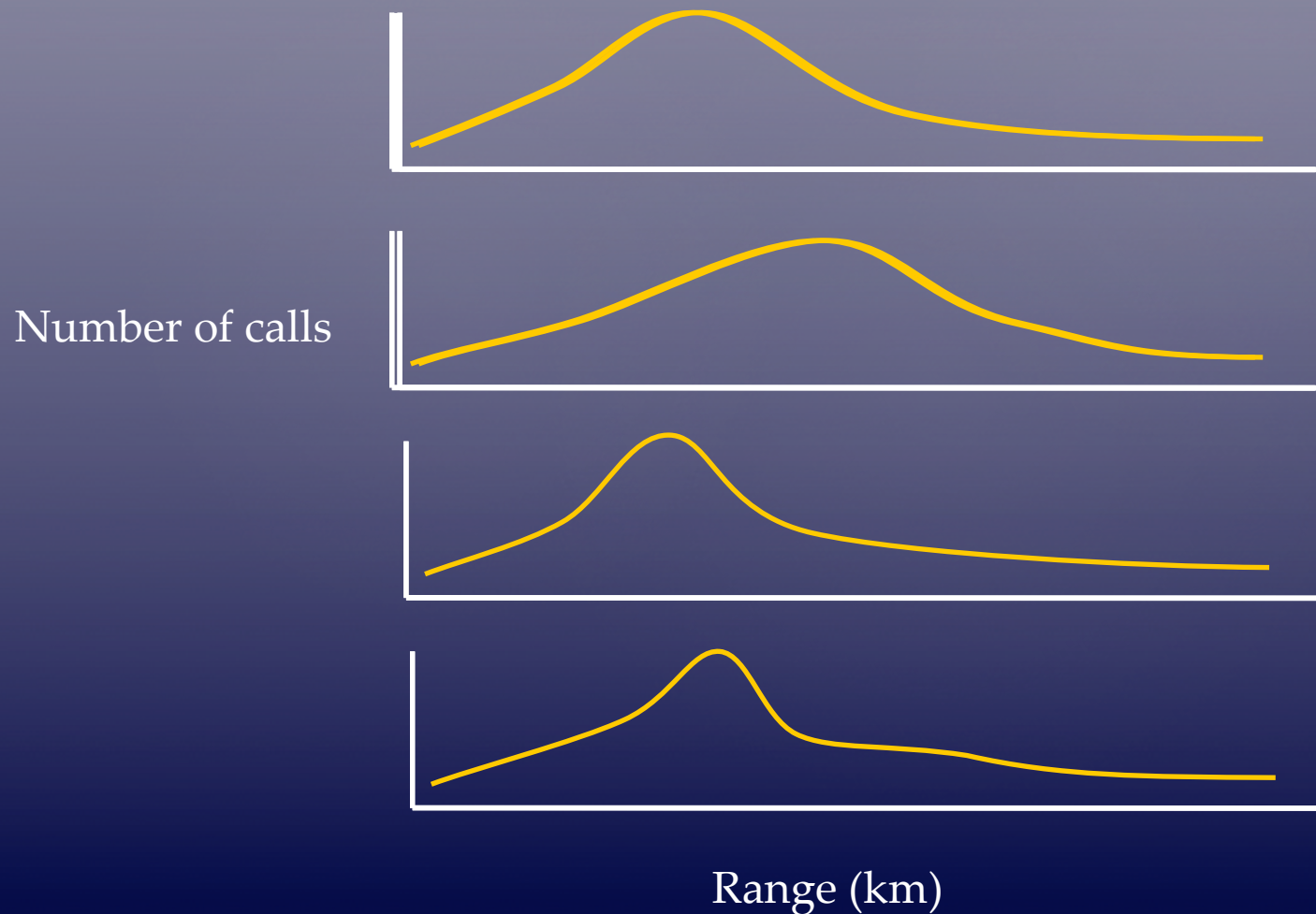
Methods - overview

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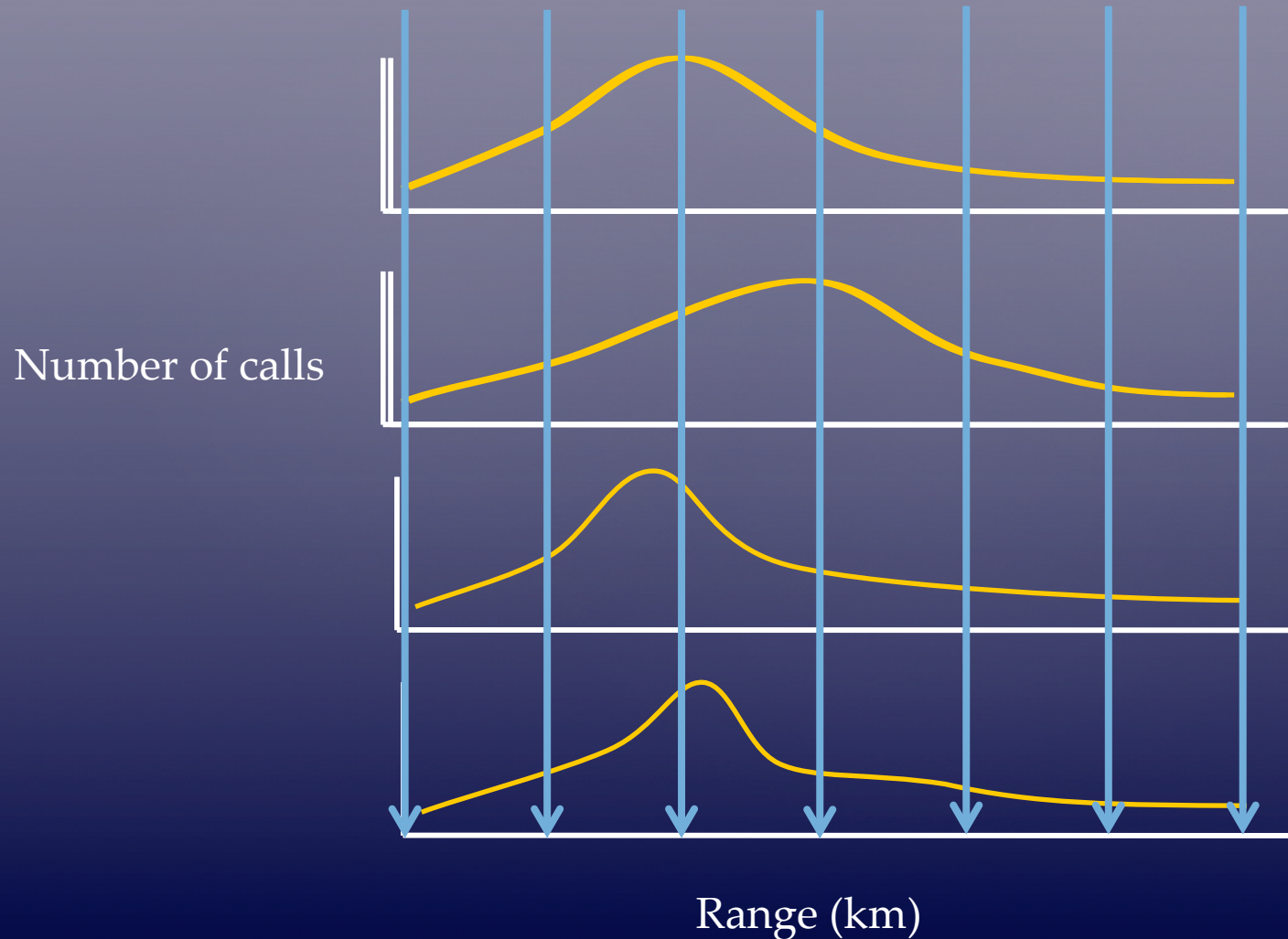Single call
corrected
for missed
calls

Range (km)

Methods - overview

- Do this for all calls along the same bearing…

Number of calls

Range (km)

Methods - overview

…and sum them across range bins

Number of calls

Range (km)

Methods - overview

- The final step is to use the no. calls in each range bin across all bearings in a spatial model

- Generalised additive model with bearing and range as 2D smooth.

Simulation study - goals

- Assess the bias in estimated abundance
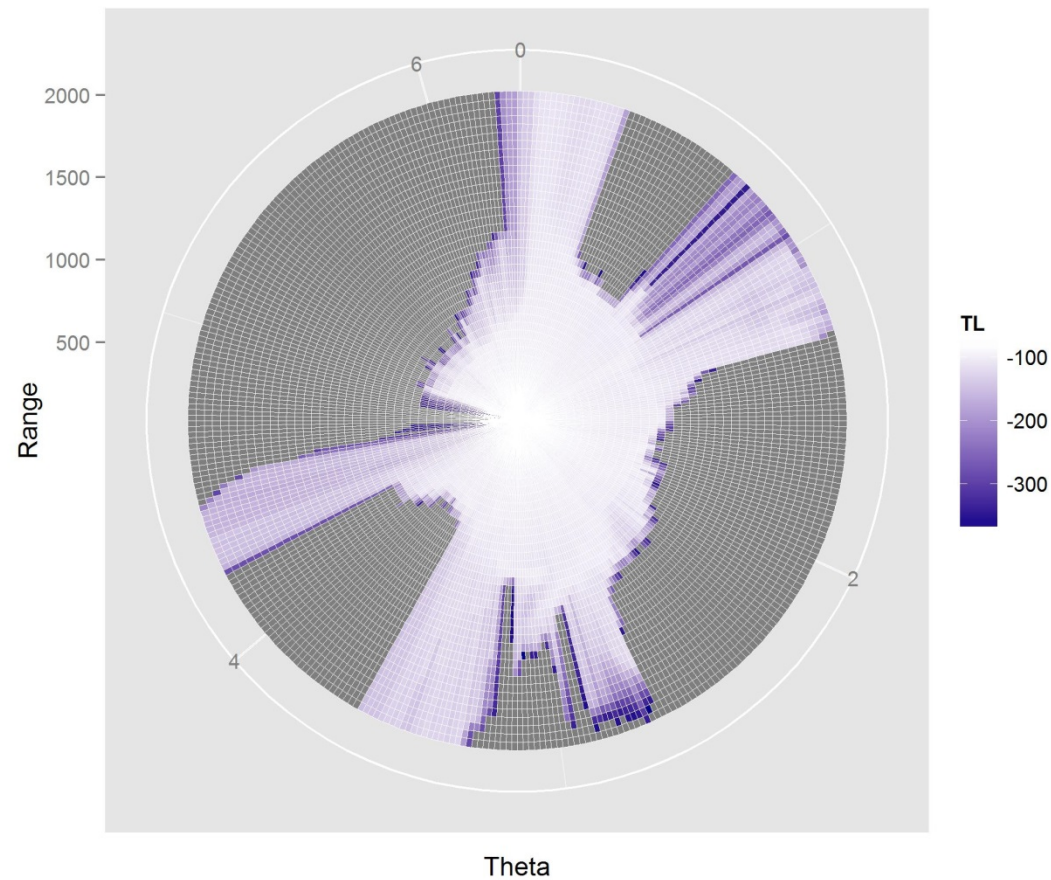
- For a range of scenarios

Simulation study - inputs

- Based on Sri Lankan blue whale calls (106 Hz at 30 m)

- SL data from literature (mean = 179 dB, sd = 2)*

- Detector characterisation from Harris (2012)

- TL model provided by K. Heaney, OASIS.

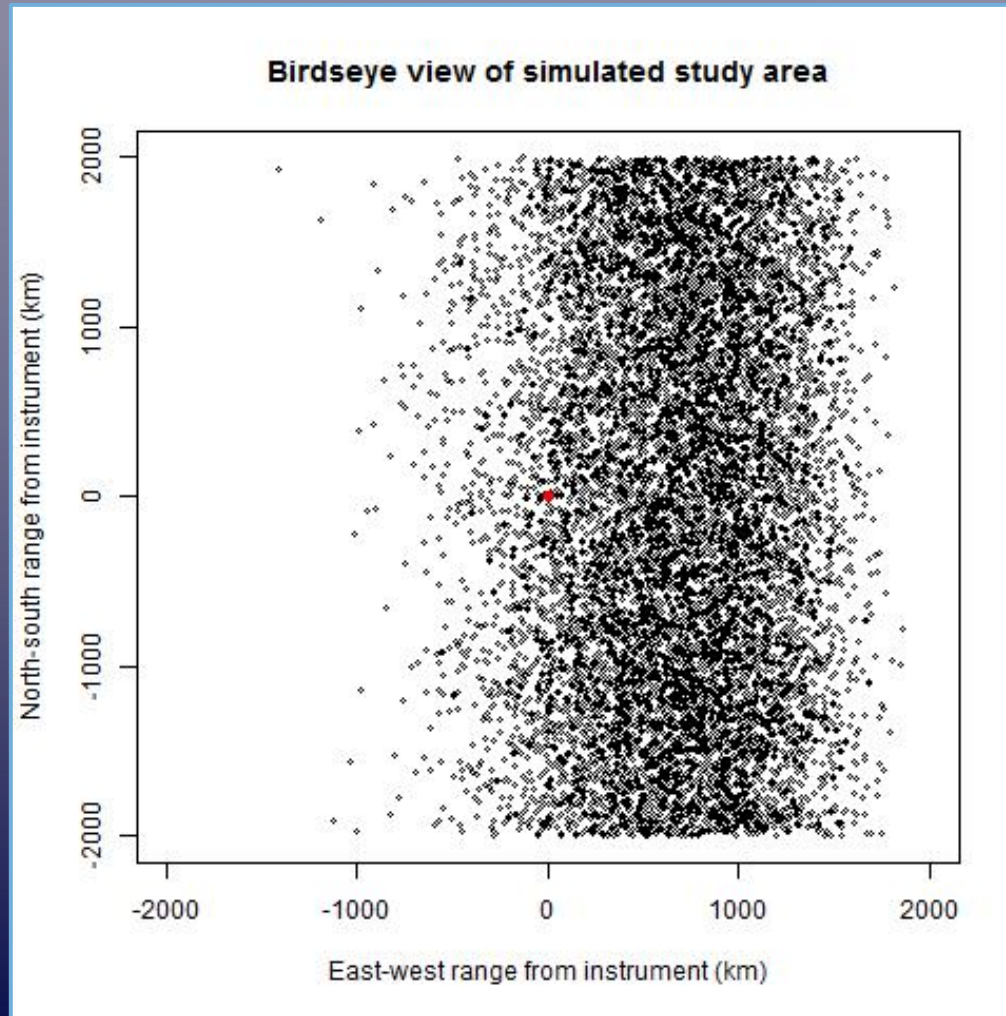- NL data (mean = 175 dB, sd = 3.5) from Harris (2012)
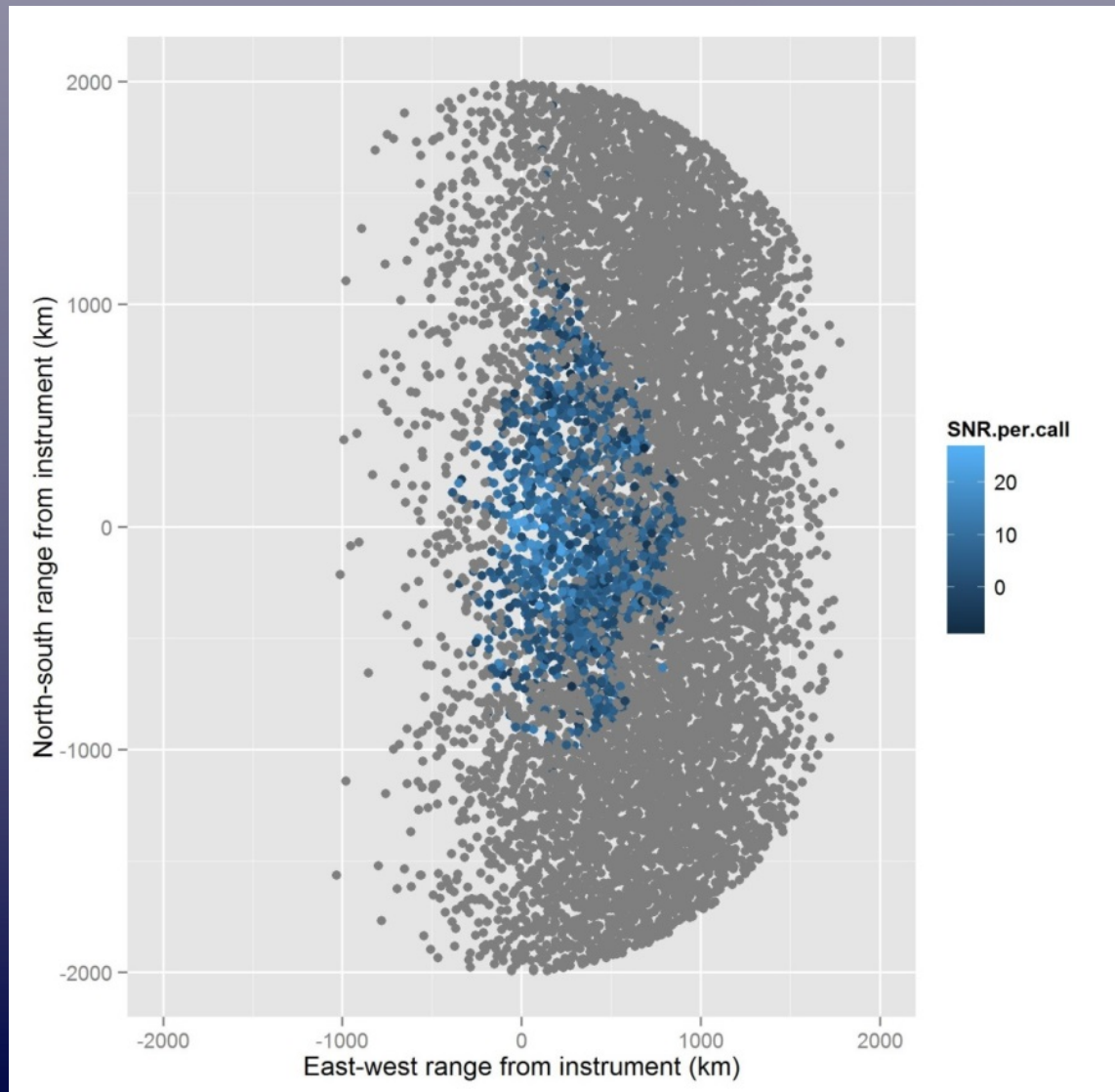
*from Gavrilov *et al.* (2011)
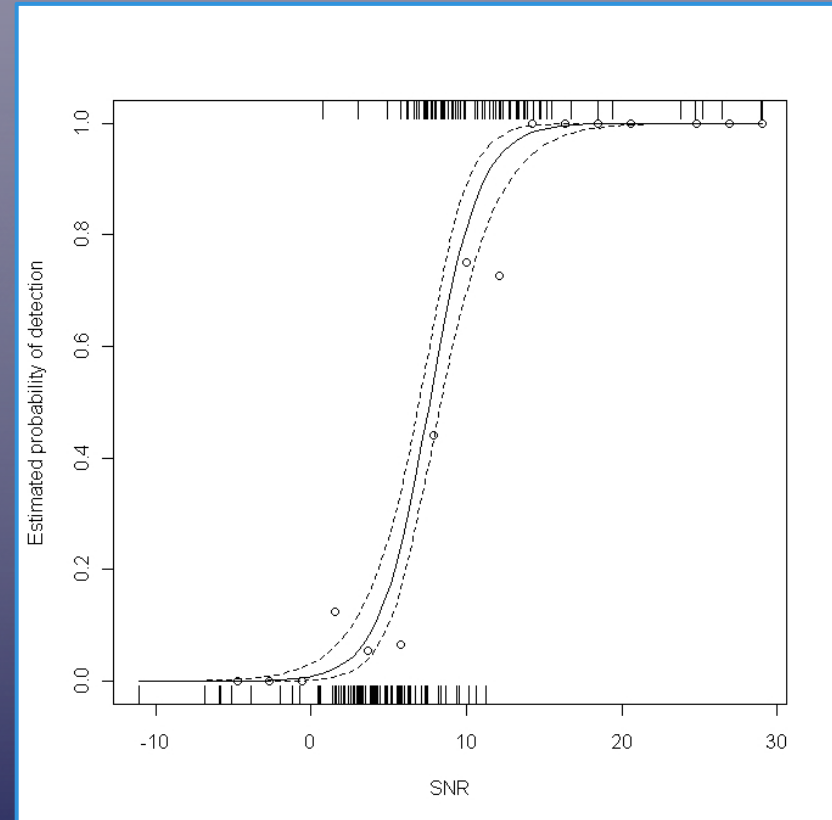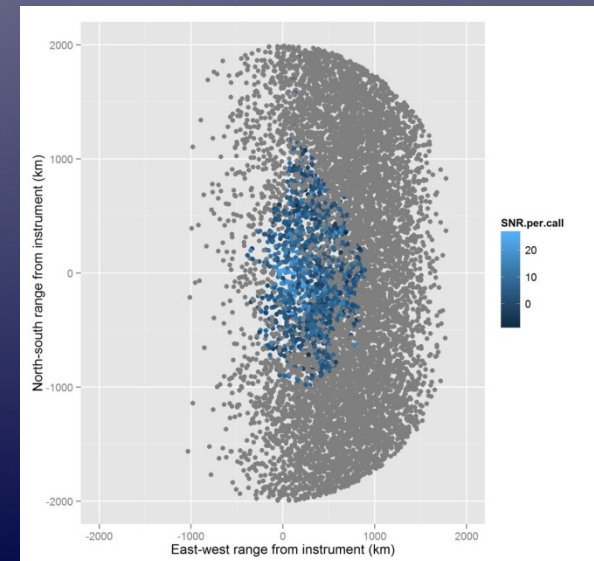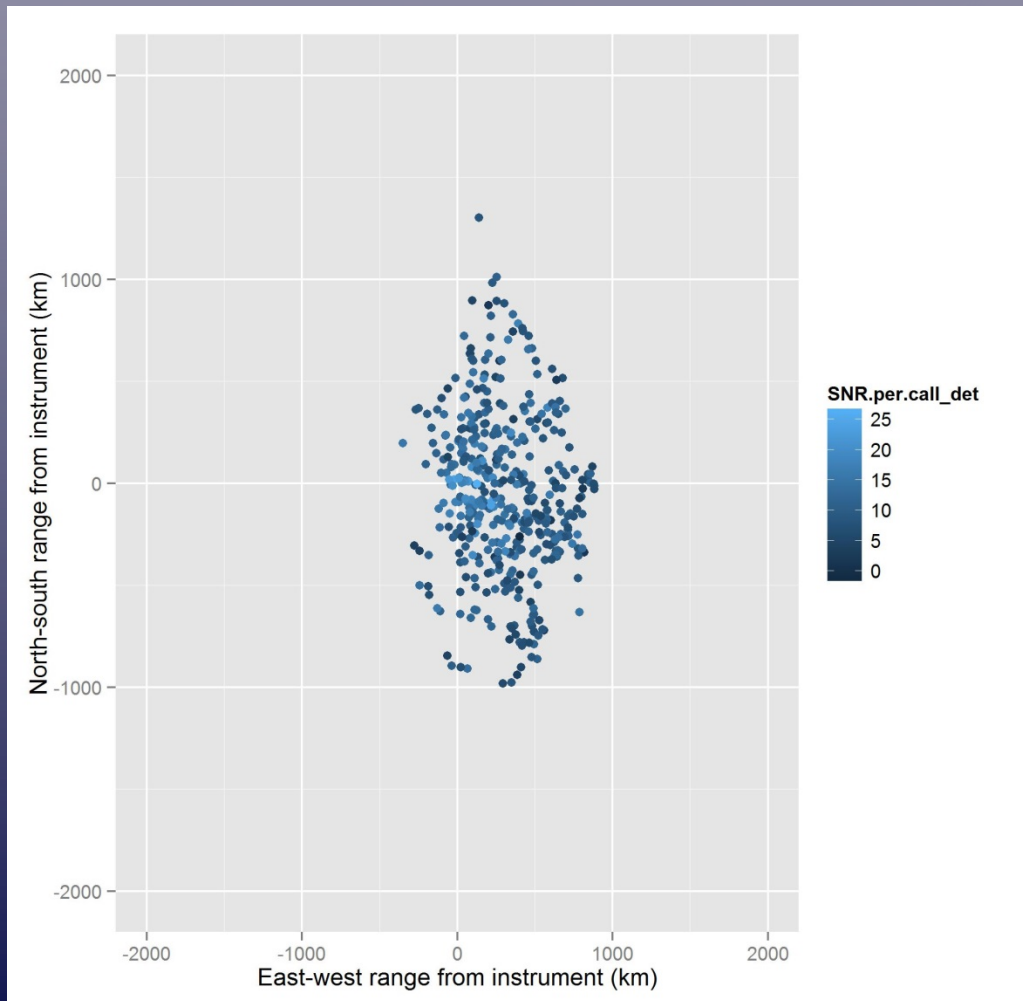
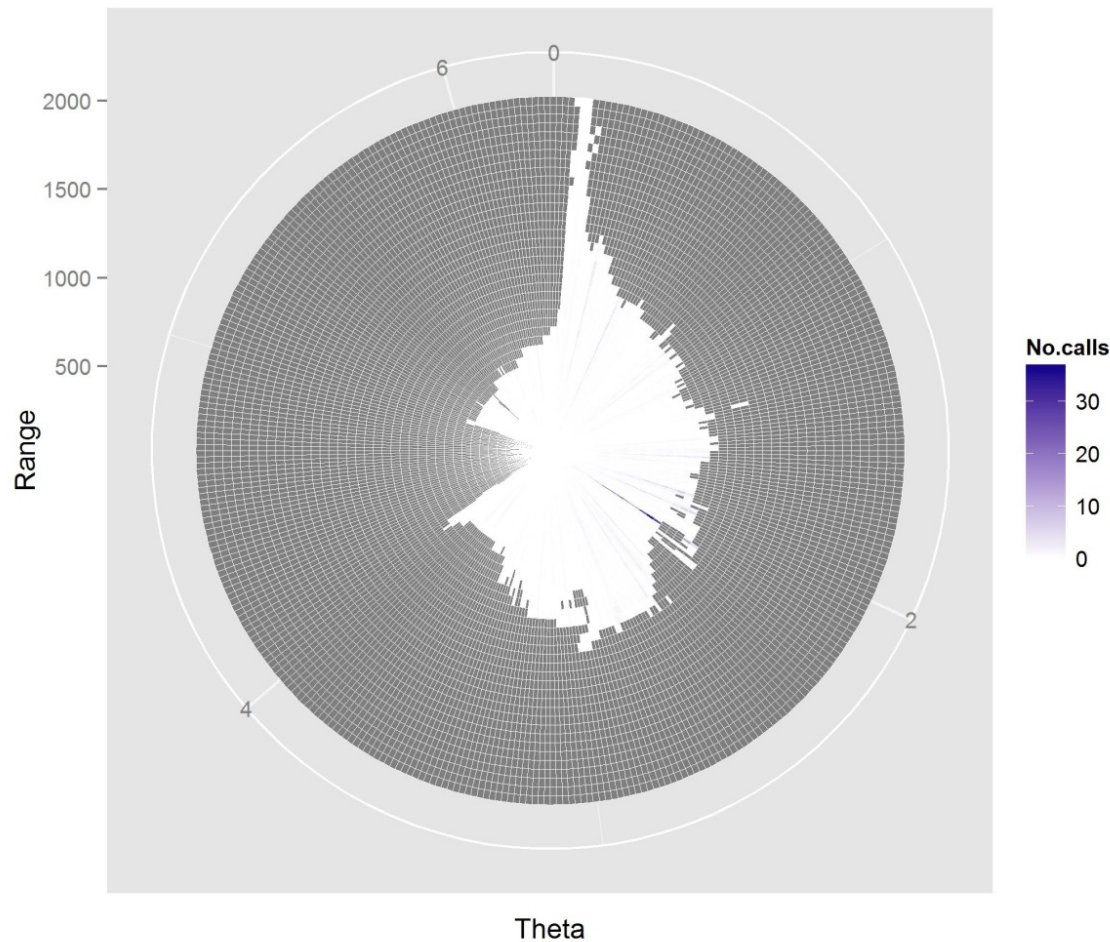# Simulation study - TL data

Simulation study – all simulated calls

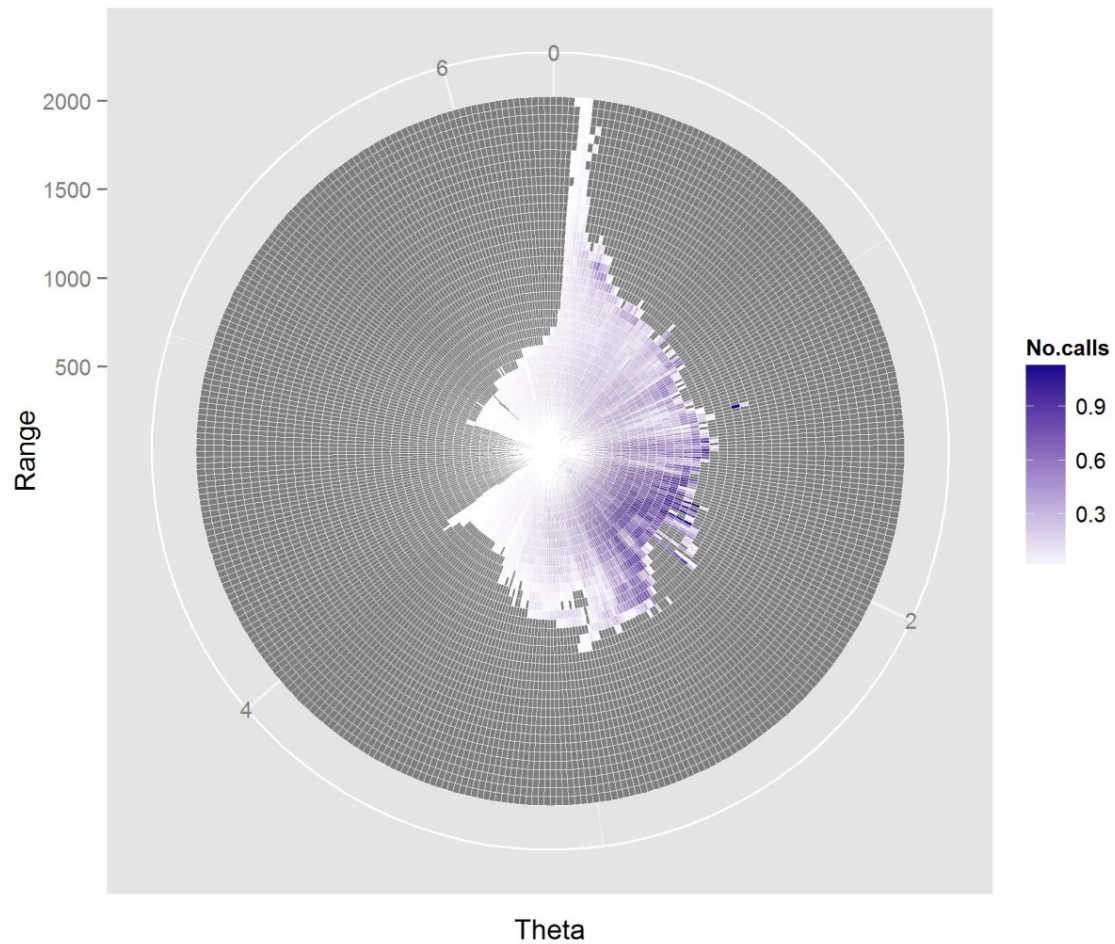# Simulation study – all simulated calls

Simulation study – all simulated calls

Simulation study – "split" calls

Simulation study – spatial model

Simulation study – results

- Based on 100 simulations.

- Median number of detections: 450 calls

- Mean TL level for non-detection: -101 dB

- Median bias: - 7%

Simulation study – extensions

- Spatial model should account for spatial autocorrelation.

- Is it better to predict over a smaller range – less bias?

- Source levels from data (possible from CTBT data).

- Run more scenarios – different distribution

- Compare with OBS system where ranging and distance sampling, a standard abundance estimation method, can be used.

- Call production rates required for animal density.
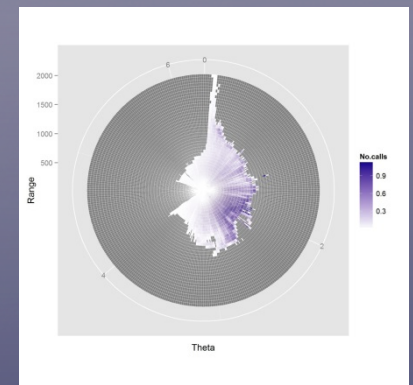
Acknowledgments

- Kevin Heaney at OASIS

- Mike Weise at the Office of Naval Research

Reference: Gavrilov, A. N., McCauley, R. D., Salgado-Kent, C., Tripovich, J., & Burton, C. (2011), Vocal characteristics of pygmy blue whales and their change over time. *Journal of the Acoustical Society of America, 130(6),* 3651-3660.