Marine Biodiversity Hub

National Environmental Science Programme

# Technical Report: Underwater noise signatures of ships in Australian waters

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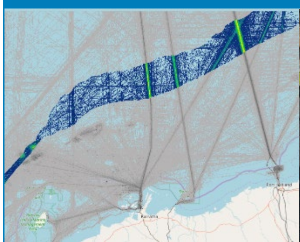
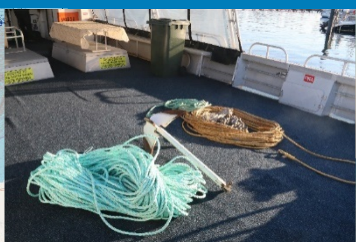
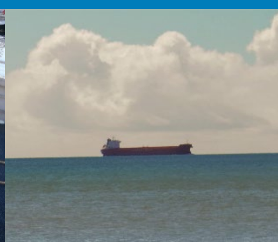
**E2 – Characterising anthropogenic underwater noise to better understand and manage impacts to marine life**

*April 2021*

*Milestone 1 (RPV4 2018)*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## Copyright



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## Important Disclaimer

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# 1. INTRODUCTION

The National Environmental Science Program within its Marine Biodiversity Hub has supported a project to quantify underwater noise from ships in Australian waters, with the ultimate goal of guiding the management of noise impacts on marine fauna. As part of this project, ship noise was recorded and archival recordings of ships from the Integrated Marine Observing System (IMOS) acoustic observatories were analysed to build a catalogue of ship noise signatures in Australian waters. These signatures will then be used to inform a spatial model of ship noise around Australia. The results of this project will feed into the management of underwater noise by the Australian Government.

This report presents the field recordings and the methodology developed for computing ship source spectra and source levels. The results of applying the software to recordings from an initial set of five IMOS deployments, spanning a total of 1463 days, are presented.

# 2. VERTICAL ARRAY RECORDINGS OF SHIP NOISE

## 2.1 International Standard for Ship Noise Measurement

The International Standardisation Organisation (ISO) has developed an international standard for recording and measuring ship noise (International Organization for Standardization, 2016, 2019). Ship noise is recorded with a vertical array of three hydrophones (Figure 1). The depths of the hydrophones are computed from the ISO-set slant angles of 15°, 30°, and 45° as the distance from the ship times the tangent of the slant angle. The distance at closest point of approach (CPA) has to be the greater of 100 m and the ship length. The minimum water depth must be the greater of 150 m or 1.5 times the ship length.

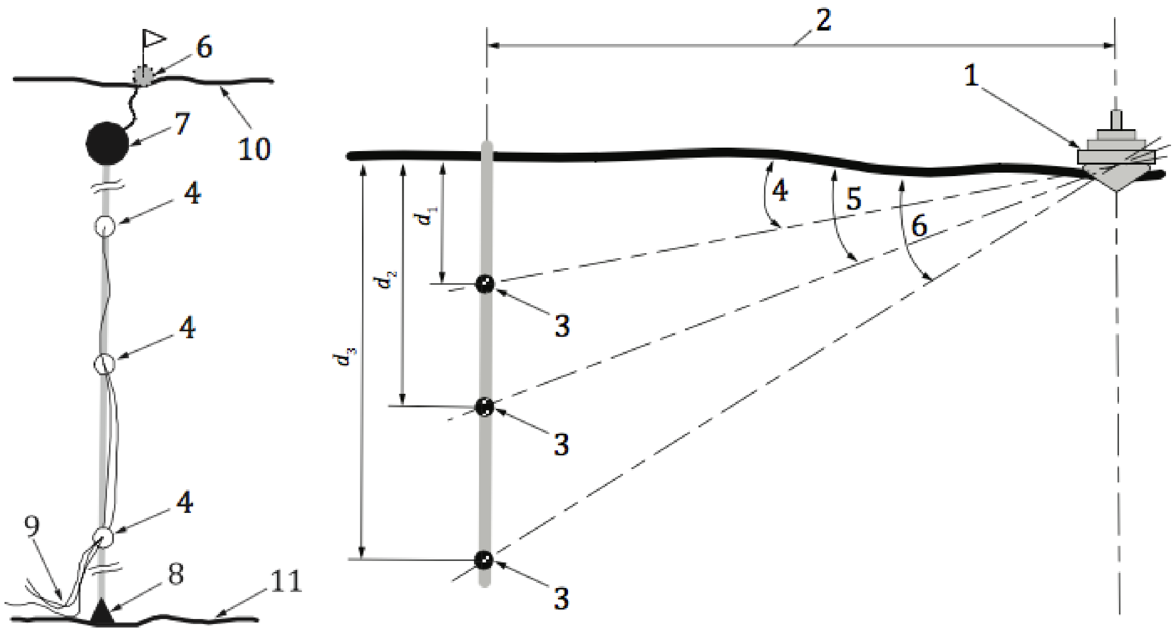



Figure 1 Left: Sketch of a vertical array for ship noise measurements showing hydrophones (4), an optional surface buoy (6), a subsurface float (7), an anchor (8), signal lines to shore (9) unless autonomous recorders are used at the locations 4, sea surface (10) and seafloor (11). Right: Sketch of a ship (1) passing at distance (2) from the hydrophone array (3), whereby the hydrophones are at slant angles 15O(4), 30O (5), and 45O(6) from the ship (International Organization for Standardization, 2016).

## 2.2 Potential Australian Sites

We looked for potential sites where the ISO requirements of water depth and range from the ship could be met using common shipping routes. The first step to find general locations was to map vessel density based on AIS data at the depths 200-500m at a selection of ports around Australia (e.g., Figure 2 and Figure 3).

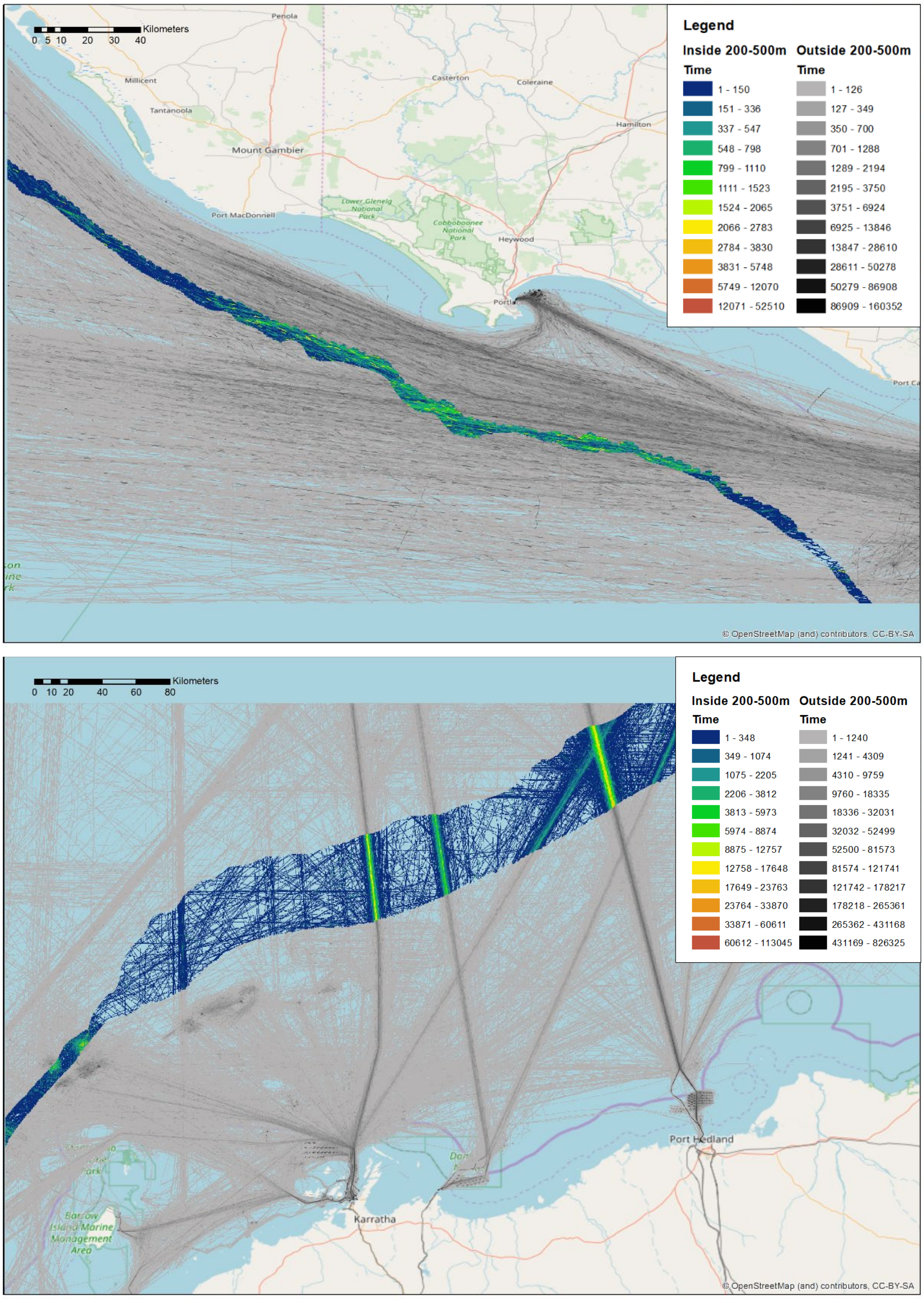



Figure 2 Mapping of AIS-equipped vessel traffic for determination of suitable logger deployment sites, for locations near Portland, VIC (top), and Port Hedland, WA (bottom).

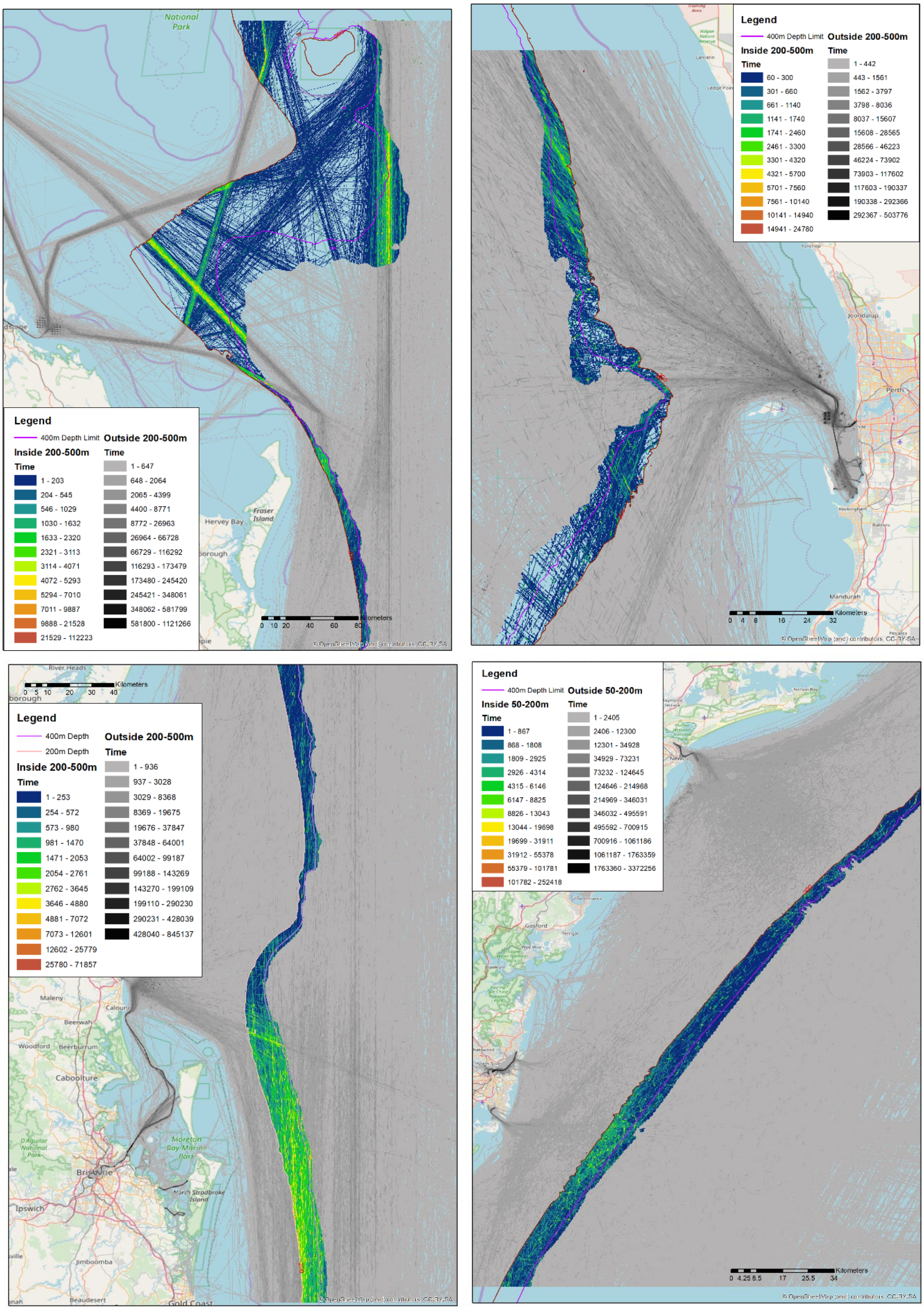



Figure 3 Mapping of AIS-equipped vessel traffic for determination of suitable logger deployment sites, for locations near Gladstone, WA (top left), Perth, WA (top right), Brisbane, QLD (bottom left), and Sydney, NSW (bottom right).

However, we require no other vessels to be within range when the vessel passes the array. Hence, more busy shipping lanes may not necessarily provide usable data as there is more chance another vessel will be in range. The second phase involved a more detailed analysis of placing a hypothetical array at the centre of each grid cell and determining how many vessels would have provided measurements of isolated sound.

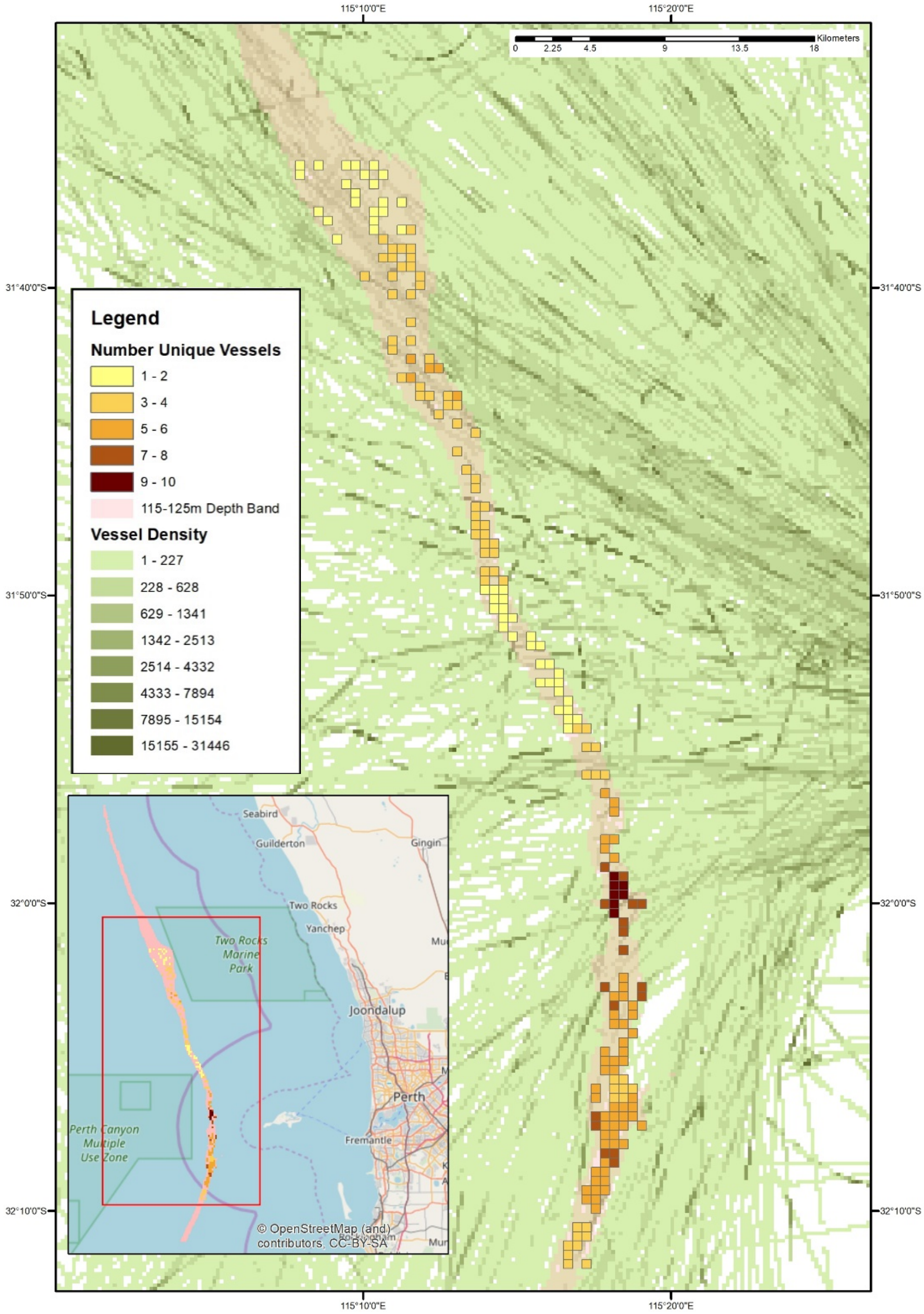



Figure 4 Number of unique vessels meeting ISO ship noise recording criteria when no other vessel is within masking range; Fremantle, WA.

There is no site where ships would routinely pass in sufficient numbers to have a sufficient sample size of recordings. However, we deployed the vertical array outside of Fremantle

Port, WA, to confirm the number of vessels that would meet criteria and to trial the vertical array for future deployment at a site where vessels could intentionally sail past the array in order to meet ISO standards.

## 2.3 Fremantle Port Deployment

The vertical array was deployed 37 nm offshore of Fremantle, WA (31°39'15.8" S, 115°10' 30.5" E) on the 14/06/2019 in approximately 120 m water depth (Figure 5, Figure 6). Deployment of the acoustic vertical array was undertaken using the Inception II 16.76 m charter vessel from Andro Maritime Services Australia. The duration of the deployment was a total of 56 days, with retrieval on 09/08/2019.

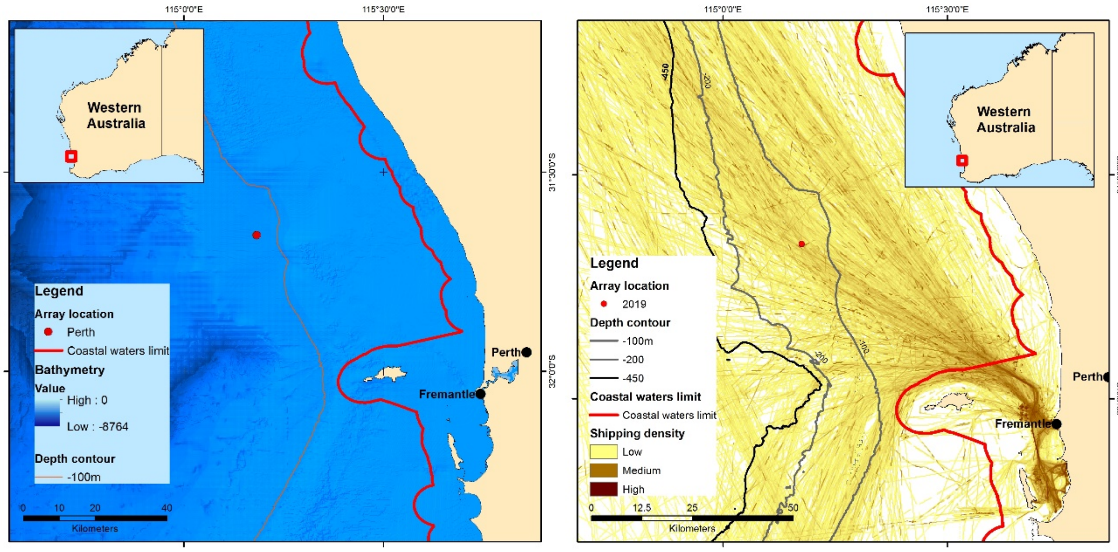



Figure 5 Left: The position of the moored vertical array in relation to Fremantle Port and the surrounding bathymetry. Right: A map of the AIS tracks of large vessels transiting north and south from Fremantle Port, with the position of the vertical array mooring highlighted

Figure 6 Photos of the vertical array. Left: The float system and SoundTrap used as an acoustic receiver. Right: The tethered system of rope and anchor used for the mooring.

The only way to obtain ISO measurements in Australian waters is by having ships sail a deliberate path over a vertical array in deep water. Given this requires a large number of participating vessels that are able to sail a detour, we switched to archival recordings from single recorders. While this methodology does not fit the ISO vertical array measurements, high-quality ship noise source levels can still be determined by using sophisticated sound propagation models.

If ISO standard measurements are to be attempted offshore of Fremantle in the future, then a water depth of approximately 450 m is necessary to satisfy the ISO standard. Figure 5 shows the distribution of vessels offshore of Fremantle relative to the 450 m bathymetry contour. Shipping distribution would either need to be moved approx. 20 km further west or deployment of the vertical array would need to be significantly further north. The limitations are that there are no defined shipping lanes in this region, or in most offshore regions of Australia, resulting in more dispersed shipping traffic and consequently density and sample size decrease. It is likely a more feasible location will be elsewhere, for example offshore of Sydney.

# 3. ARCHIVAL (IMOS) RECORDINGS OF SHIP NOISE

Data processing for each deployment required a number of steps, each of which is described in more detail in the following subsections.

1. Extraction of AIS data relevant to the deployment and screening to only include ship passes that came within 1 km of the recorder while there were no other vessels within 5 km.
2. Preprocessing of acoustic recordings to calculate received level spectra in 1-minute blocks.
3. Use of an acoustic propagation model to pre-calculate the likely acoustic propagation loss in the vicinity of the recorder as a function of frequency and range, depth and bearing from the recorder.
4. Using the AIS information for each vessel pass to determine the range and bearing of the ship from the recorder at the centre-time of each spectral block.
5. Combing the received level spectra and modelled propagation for the geometry determined from the AIS information to calculate an equivalent monopole source spectrum for the ship corresponding to each spectral block.
6. For each pass, a block of signal without ship noise was manually selected and processed in the same way as the ship noise data to provide an ambient noise background level.

Step 1 was carried out by CSIRO. Existing CMST software was used to carry out Step 2, and a GUI based MATLAB (The MathsWorks Inc., Natick, MA, USA) program called Ship Noise Acoustics (SNAC) was written by CMST to carry out the remaining steps.

## 3.1 Extraction of AIS Data

CSIRO carried out extraction of AIS data from their 5-minute sub-sampled AIS database. The data was then processed/cleaned (see previous NESP project C5) and interpolated to 60-s time steps, to identify when vessels passed within 1 km of the recorder while there were no other vessels within 5 km. With a range ratio of 1:5, any other vessels would produce received levels about 14 dB (= 20 x log10(5)) below those of the target vessel and hence not interfere with the target vessel's source characterisation.

Information about the useful tracks was provided to CMST in the form of nnnn_Passes.csv files and nnnn_15km.csv files, where nnnn represents the corresponding acoustic recording set number (see Table 1). Each row of a Passes file gave details of a period a vessel qualified (i.e., was within 1 km of the recorder and no other vessel within 5 km), whereas the 15 km files had multiple lines corresponding to each pass identified in the Passes file, that gave details of the AIS line segments that made up that pass while the vessel was within 15 km of the recorder. See Appendix C for further details.

Table 1 Summary of processed datasets

| Set number | Latitude Deg Min | Long-itude Deg Min | Start time | End time | Duration (days) | Description | Number of ship passes |
|---|---|---|---|---|---|---|---|
| 3154 | 31 53.053 | 115 0.813 | 10/08/2012 12:15 | 14/06/2013 10:00 | 307.9 | IMOS Perth Canyon 2012-2013 | 11 |
| 3274 | 38 32.218 | 141 14.854 | 30/12/2013 9:30 | 27/11/2014 2:15 | 331.7 | IMOS Portland 2014 | 124 |
| 3315 | 31 52.033 | 115 0.068 | 28/11/2013 17:00 | 31/03/2014 15:00 | 122.9 | IMOS Perth Canyon 2013-2014 | 11 |
| 3376 | 31 50.530 | 115 0.824 | 28/11/2013 17:05 | 4/11/2014 4:35 | 340.5 | IMOS Perth Canyon 2013-2014 | 16 |
| 3445 | 31 52.656 | 115 0.656 | 5/01/2016 17:00 | 31/12/2016 5:00 | 360.5 | IMOS Perth Canyon 2016 | 32 |

## 3.2 Pre-processing of Acoustic Recordings

Pre-processing was carried out in MATLAB programs that form part of CMST's Characterisation Of Recorded Underwater Sound (CHORUS) toolbox (Gavrilov and Parsons, 2014). These routines read the raw binary data files, applied a calibration based on a recorded white noise calibration signal and known hydrophone sensitivity to convert to received acoustic pressure, and then calculated power density spectra based on a 1-s FFT duration, a Hamming window, and averaging of the spectra over 60-s blocks. The resulting spectra had a frequency resolution of 1 Hz and were stored in MATLAB binary .mat files, with each file containing 5 days of data.

## 3.3 Propagation Loss Modelling

Acoustic propagation loss modelling was carried out using the well-known parabolic equation propagation model, RAMGeo (Collins, 1993) which was incorporated into SNAC using an interface adapted from CMST's standard MATLAB acoustic modelling front-end, Enviroseis. For each deployment, RAMGeo was used to model acoustic propagation in 24 range-depth slices at 15° azimuth intervals, centred on the recorder position. Acoustic reciprocity dictates that the propagation loss for propagation from A to B is the same as from B to A, and RAMGeo is designed to calculate the propagation loss from one source location to many receiver locations, so the modelling was most efficiently done by specifying the recorder position and depth as the RAMGeo source location, and the vessel position as the RAMGeo receiver location. The depth of the vessel source (RAMGeo receiver) was assumed to be 3 m.

Bathymetry was interpolated from the Geoscience Australia 0.15' bathymetry grid (Whiteway, 2009), and representative sound speed profiles were obtained from the World Ocean Atlas

(Locarnini et al., 2006) The April-June profiles were chosen as being closest to average conditions throughout the year. The seabed properties were chosen to be representative of a fine sand seabed with the parameters given in Table 2. RAMGeo is unable to model elastic effects so shear wave parameters were not included in the seabed model, but are likely to be negligible for the soft seabeds found at the depths where the recorders were deployed.

Table 2 Assumed seabed geoacoustic properties

| | | |
|---|---|---|
| Density | 1941 kg/m$^3$ | Hamilton, 1980 |
| Compressional wave speed | 1749 m/s | Hamilton, 1980 |
| Compressional wave attenuation | 0.8 dB per wavelength | Jensen *et al.*, 2011 |

Propagation loss was calculated along each azimuth out to a range of 10 km. These calculations were carried out at 1/3 octave frequency intervals from 2 Hz to 2.5 kHz and then range averaging was used as a surrogate for frequency averaging over each band as described in Harrison and Harrison, 1995.

## 3.4 Range and Bearing Calculations

The AIS data and recorder locations were converted from geographical coordinates (latitude/longitude) to Universal Transverse Mercator (UTM) coordinates (Easting, Northing). UTM is a rectangular coordinate system with equal scaling in the easting and northing directions, so the required range and bearing calculations were then straightforward. Earth curvature effects were not included because they are insignificant over the ranges involved here.

## 3.5 Source Spectrum Calculation

The Easting and Northing of the ship relative to the recorder were linearly interpolated to the centre time of each spectral block and then the corresponding range and bearing were calculated. Range and bearing were then used with nearest-neighbour interpolation to obtain the corresponding propagation loss for each frequency band.

The received power density spectrum was integrated over each frequency band and converted to logarithmic units. The corresponding propagation loss was then subtracted to obtain the source level in each band (dB re 1 μPa @ 1 m), which can readily be converted to the band spectral level (dB re 1 μPa$^2$/Hz @ 1 m) by subtracting $10\log_{10} W$, where $W$ is the width of the corresponding band (Hz).

## 3.6 Noise Calculations

To allow assessment of the validity of the calculated ship spectra, the SNAC processing pipeline for each ship pass included display of the spectrogram of the corresponding spectral file with the time of the ship pass marked. The user was then prompted to select a period of ambient noise at a time when there was no ship noise visible in the spectrogram, but the noise conditions were otherwise similar to those during the pass. This noise data was then processed the same way as the data from the ship pass and an equivalent noise source spectrum calculated. This was compared to the calculated ship source spectrum so the sections of the spectrum that were dominated by sound from the ship could be distinguished from those that only included ambient noise. Although only one noise spectrum was used per pass, the range, and hence propagation loss, were different for each block of data, so there was also a different equivalent noise source spectrum for each block.

# 4. RESULTING SOURCE SPECTRA OF SHIP NOISE

Ship source spectra for each valid pass are plotted in 1/3 octave bands in Appendix A. The spectra calculated from each 1-minute block during which the ship was between 8 km and 1 km of the recorder are plotted, along with the corresponding noise estimates. An identical set of plots with additional vessel range and speed information included in legends can be found in Appendix B.

Figures 7 to 13 summarise this information by overlaying an averaged source spectrum for each vessel pass on a single plot for each vessel class. Spectral frequency bins with a signal-to-noise ratio (SNR) less than 6 dB have been excluded from the averaging process. Note that each of the class names used in the captions encompasses several different AIS "vessel types". See Appendix D for details.

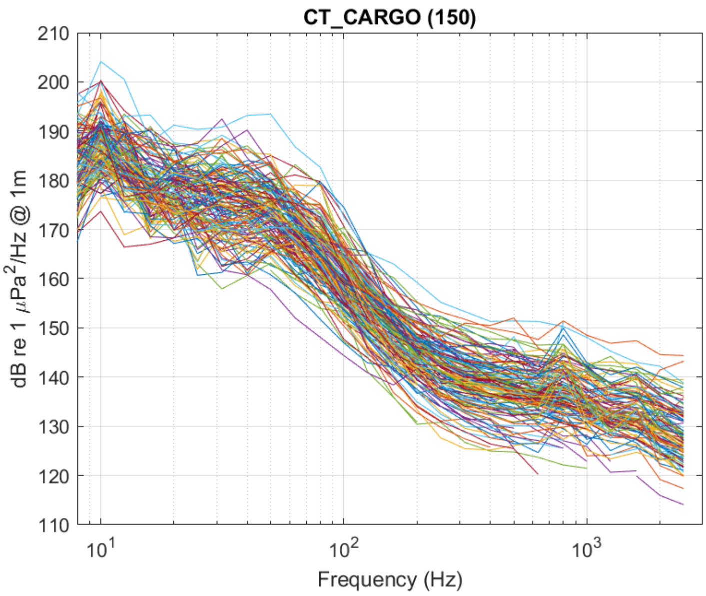



Figure 7 Estimated ship noise source spectra from all 150 CT_CARGO (cargo) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

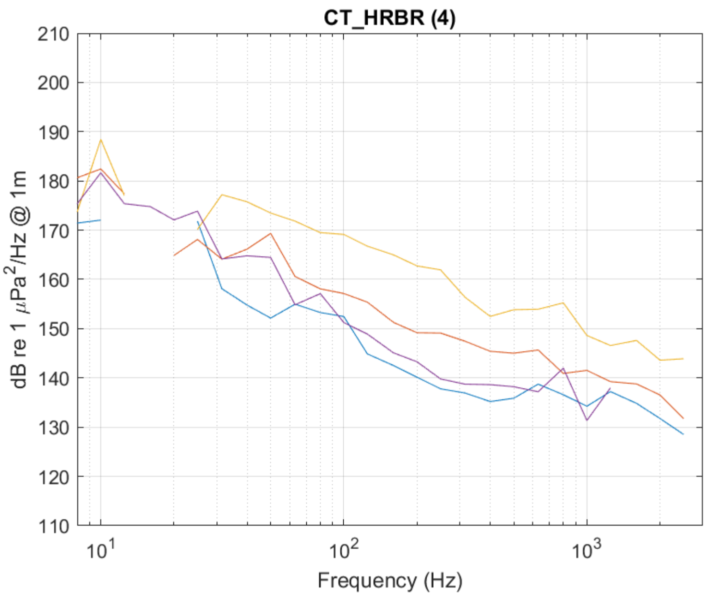



Figure 8 Estimated ship noise source spectra from all 4 CT_HRBR (harbour) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

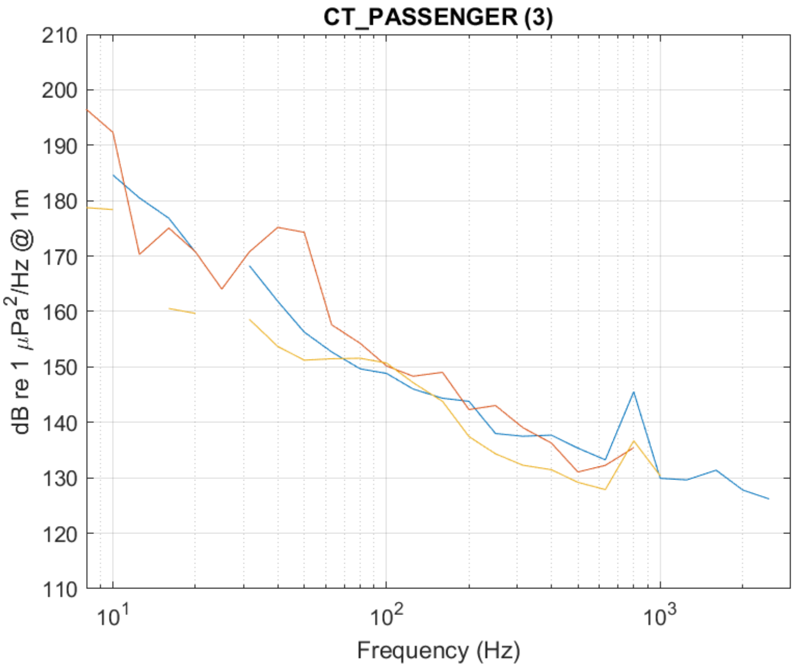



Figure 9 Estimated ship noise source spectra from 2 CT_PASSENGER (cruise ship) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

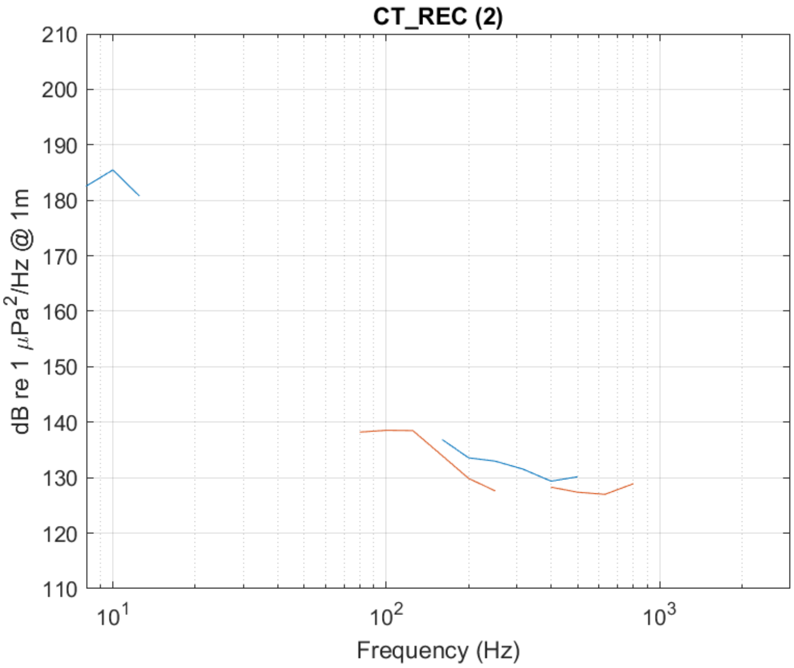



Figure 10 Estimated ship noise source spectrum from 2 CT_REC (recreational) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

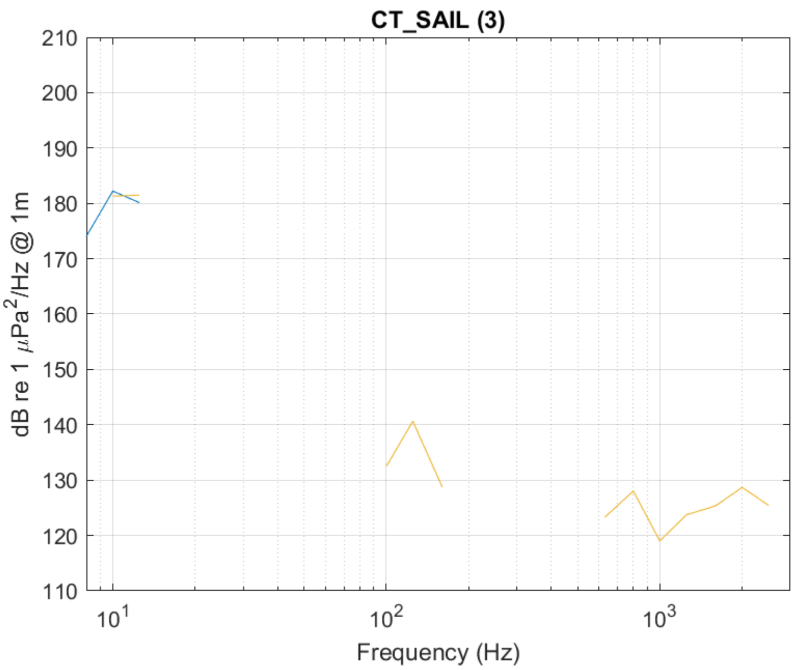



Figure 11. Estimated ship noise source spectra from all 3 CT_SAIL (sailing) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

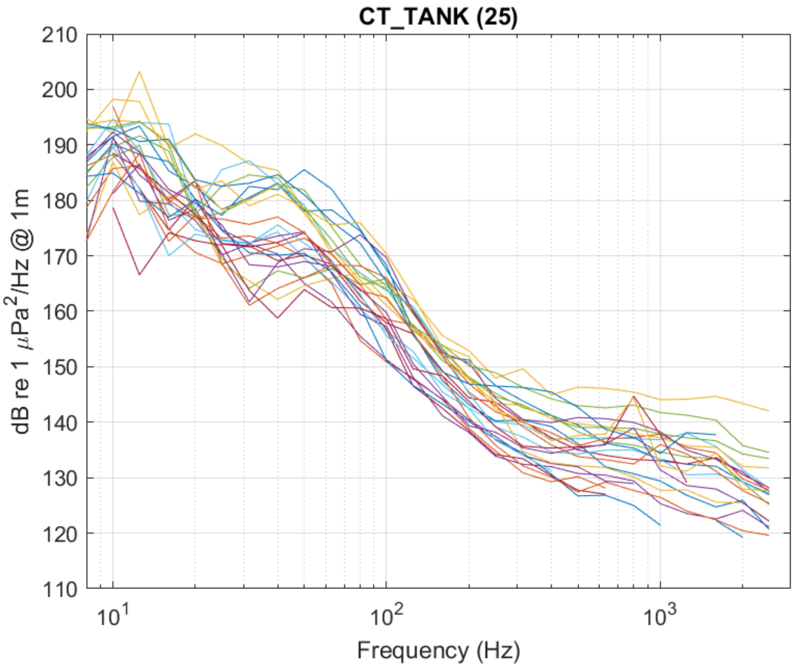



Figure 12. Estimated ship noise source spectra from all 25 CT_TANK (tanker) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

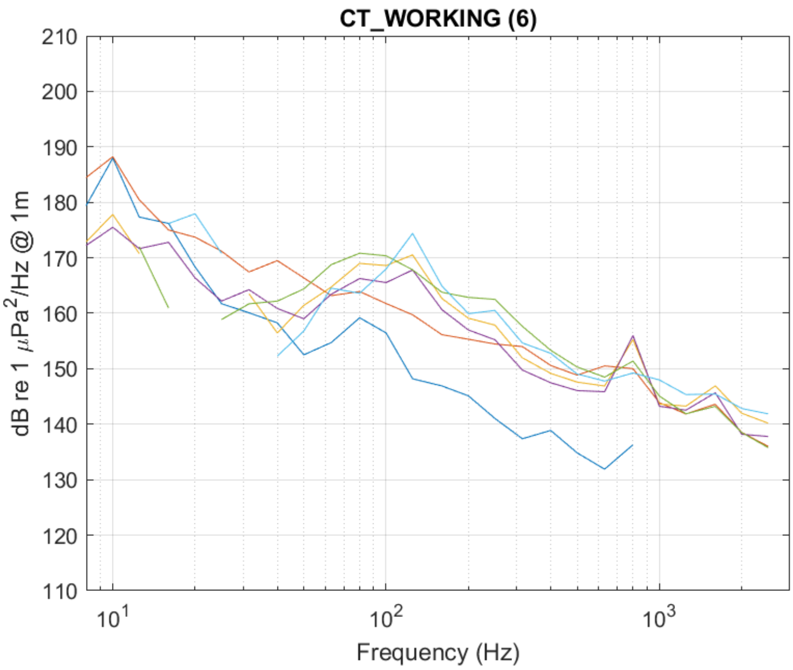



Figure 13. Estimated ship noise source spectra from all 6 CT_WORKING (working) class vessel passes from all processed data sets. Segments of source spectra with a SNR less than 6 dB have been excluded.

Two vessel types, CT_CARGO (cargo vessels) and CT_TANK (tankers) had sufficient valid passes to allow percentile spectra to be calculated, which are plotted in Figure 14 and Figure 15. When interpreting these plots, note that 75% of measured source spectra were below the

75% line at a given frequency, and similarly for the other percentile values. The 50% percentile is the median.

# 5. CONCLUSIONS

The goal of this project was to develop a catalogue of ship noise source spectra by vessel type. As ship noise also varies by load, speed, and aspect angle, a large number of recordings are needed to also quantify ship noise as a function of these parameters. While CMST has a lot of archival recordings, AIS data become unreliable prior to 2012. Unfortunately, the Integrated Marine Observing System abandoned its passive acoustic observatories in 2017, thus limiting the amount of archival data available for this project. Passive acoustics are also recorded by CMST on behalf of the Department of Defence and offshore hydrocarbon companies and CMST will seek permission to use some of this data for the purpose of quantifying ship noise in future.

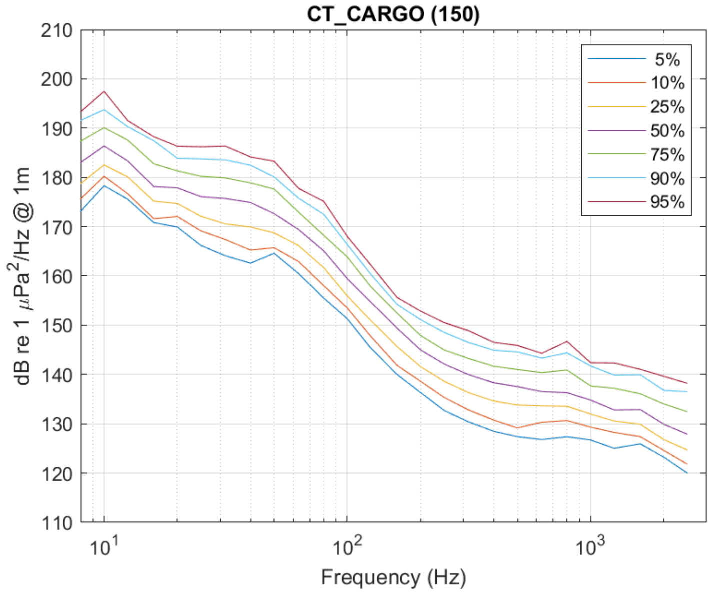



Figure 14. Noise percentile source spectra for the CT_CARGO (cargo vessel) class.

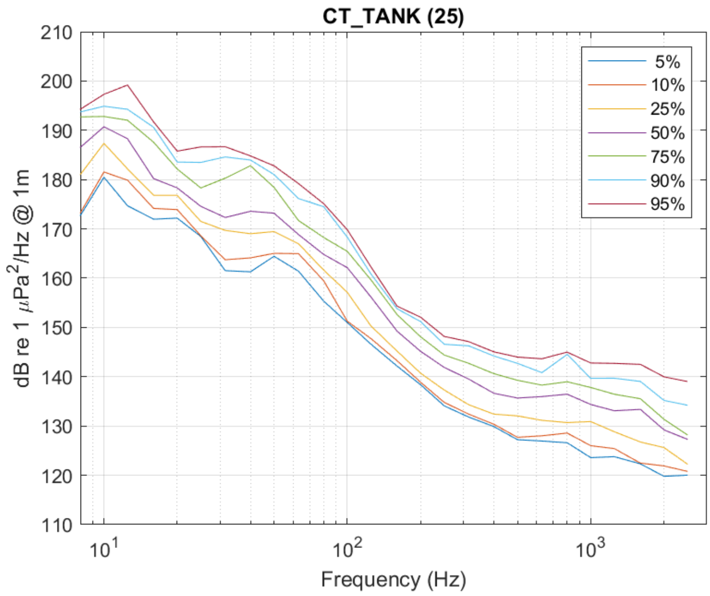



Figure 15. Noise percentile source spectra for the CT_TANK (tanker) class.

# REFERENCES

Collins, M. D. (1993). A split-step Padé solution for the parabolic equation method. *The Journal of the Acoustical Society of America, 93*(4), 1736-1742, doi: 10.1121/1.406739.

Gavrilov, A. N., and Parsons, M. J. G. (2014). A Matlab tool for the characterisation of recorded underwater sound (CHORUS). *Acoustics Australia, 42*(3), 190-196.

Hamilton, E. L. (1980). Geoacoustic modelling of the sea floor. *The Journal of the Acoustical Society of America, 68*(5), 1313-1340, doi: 10.1121/1.385100.

Harrison, C. H., and Harrison, J. A. (1995). A simple relationship between frequency and range averages for broadband sonar. *The Journal of the Acoustical Society of America, 97*(2), 1314-1317, doi: 10.1121/1.412172.

International Organization for Standardization. (2016). Underwater acoustics—Quantities and procedures for description and measurement of underwater sound from ships—Part 1: Requirements for precision measurements in deep water used for comparison purposes (ISO 17208-1). Geneva, Switzerland.

International Organization for Standardization. (2019). Underwater acoustics—Quantities and procedures for description and measurement of underwater sound from ships—Part 2: Determination of source levels from deep water measurements (ISO 17208-2). Geneva, Switzerland.

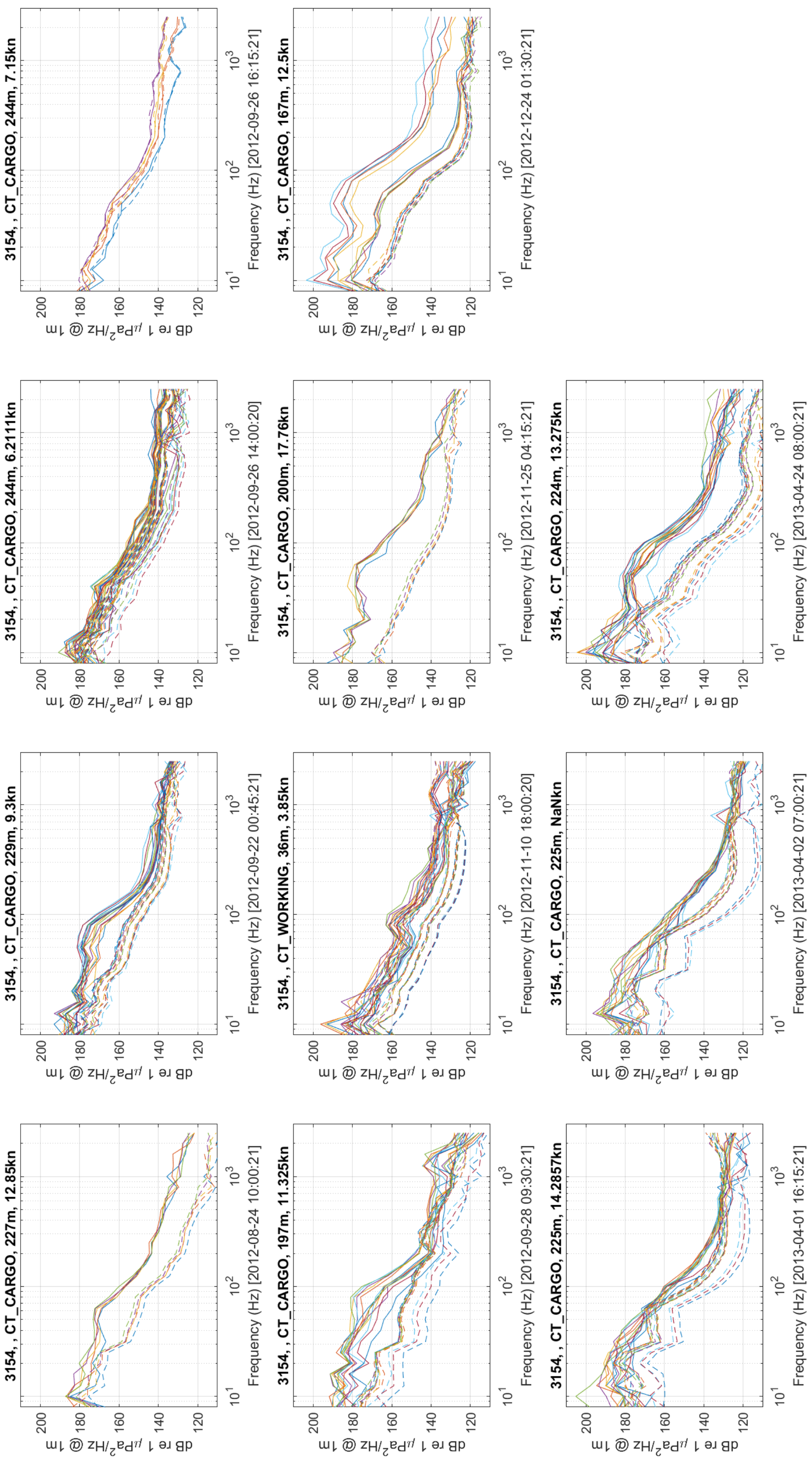
Jensen, F. B., Kuperman, W. A., Porter, M. B., and Schmidt, H. (2011). *Computational Ocean Acoustics* (2nd ed.). New York: Springer-Verlag.

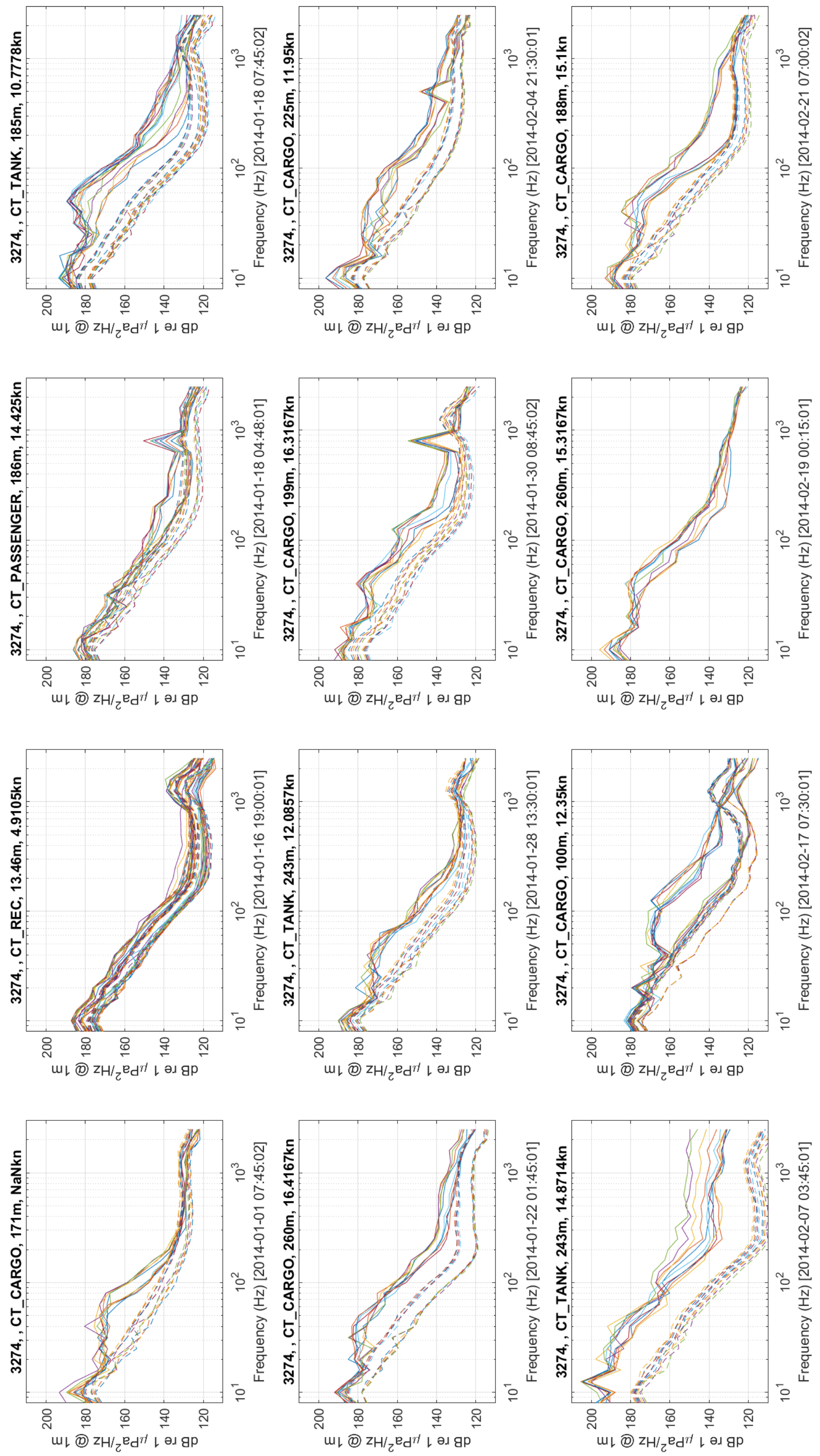
Locarnini, R. A., Mishonov, A. V., Antonov, J. I., Boyer, T. P., Garcia, H. E., and Levitus, S. (2006). *World Ocean Atlas* (NESDIS 61): National Oceanic and Atmospheric Administration.

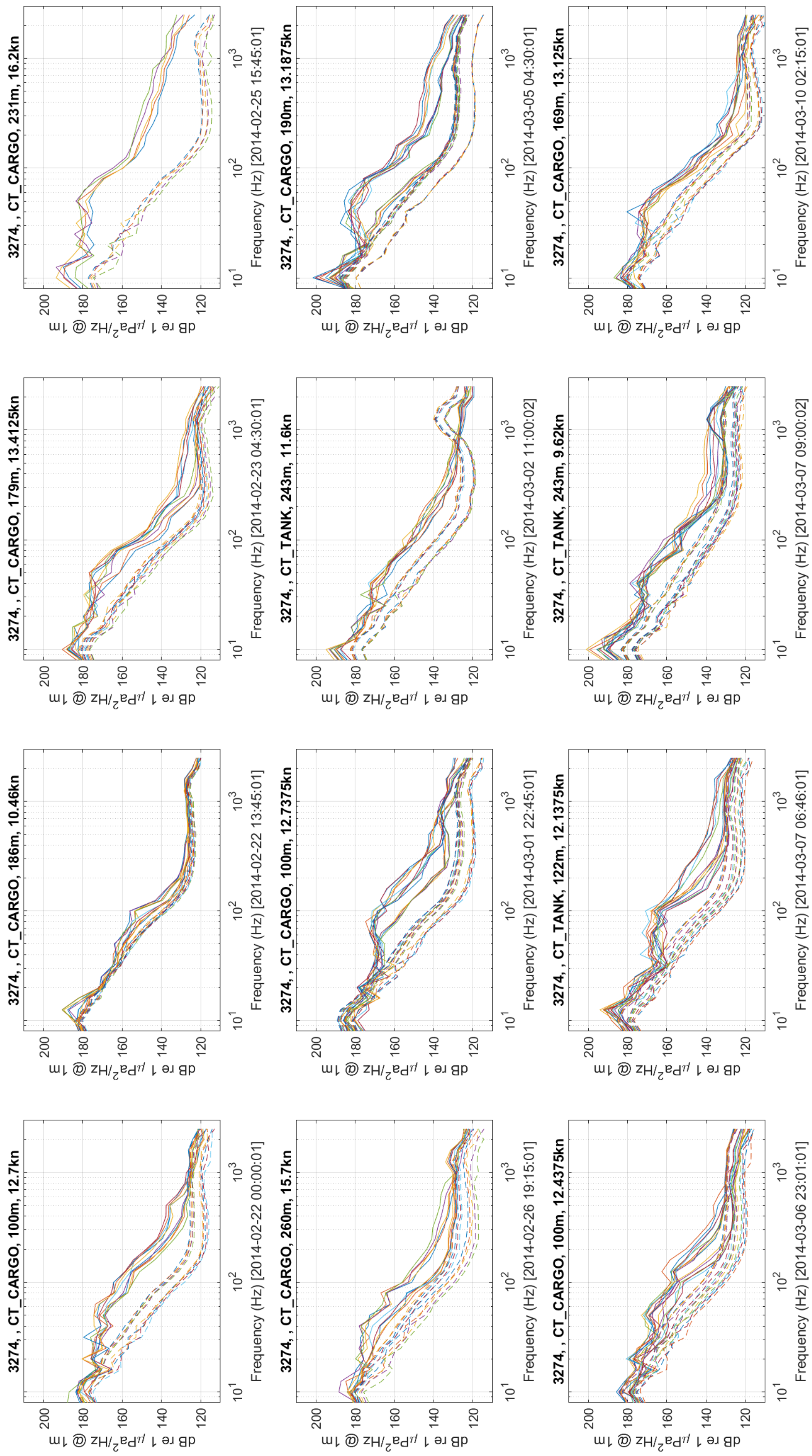
Whiteway, T. (2009). Australian bathymetry and topography grid. *Geoscience Australia, Canberra*.

# APPENDIX A – SOURCE SPECTRA FROM INDIVIDUAL SHIP PASSES (NO LEGENDS)

The following figures show calculated monopole source spectra for all processed vessel passes, assuming a source depth of 3 m. In each plot, the solid lines are the calculated source spectra for each 1-minute processing frame in which recorded acoustic data was available during the pass and broken lines are estimated equivalent source spectra of the ambient noise. Line colours correspond between these two sets of curves – see Appendix B for a version of the same plots that includes legends giving the distance from the hydrophone and vessel speed for each frame. NaN indicates no data available.


3154, , CT_CARGO, 244m, 7.15kn
Frequency (Hz) [2012-09-26 16:15:21]
3154, , CT_CARGO, 167m, 12.5kn
Frequency (Hz) [2012-12-24 01:30:21]
3154, , CT_CARGO, 244m, 6.2111kn
Frequency (Hz) [2012-09-26 14:00:20]
3154, , CT_CARGO, 200m, 17.76kn
Frequency (Hz) [2012-11-25 04:15:21]
3154, , CT_CARGO, 224m, 13.275kn
Frequency (Hz) [2013-04-24 08:00:21]
3154, , CT_CARGO, 229m, 9.3kn
Frequency (Hz) [2012-09-22 00:45:21]
3154, , CT_WORKING, 36m, 3.85kn
Frequency (Hz) [2012-11-10 18:00:20]
3154, , CT_CARGO, 225m, NaNkn
Frequency (Hz) [2013-04-02 07:00:21]
3154, , CT_CARGO, 227m, 12.85kn
Frequency (Hz) [2012-08-24 10:00:21]
3154, , CT_CARGO, 197m, 11.325kn
Frequency (Hz) [2012-09-28 09:30:21]
3154, , CT_CARGO, 225m, 14.2857kn
Frequency (Hz) [2013-04-01 16:15:21]
dB re 1 μPa²/Hz @ 1m


3274, , CT_TANK, 185m, 10.7778kn
Frequency (Hz) [2014-01-18 07:45:02]
3274, , CT_PASSENGER, 186m, 14.425kn
Frequency (Hz) [2014-01-18 04:48:01]
3274, , CT_REC, 13.46m, 4.9105kn
Frequency (Hz) [2014-01-16 19:00:01]
3274, , CT_CARGO, 171m, NaNkn
Frequency (Hz) [2014-01-01 07:45:02]
3274, , CT_CARGO, 225m, 11.95kn
Frequency (Hz) [2014-02-04 21:30:01]
3274, , CT_CARGO, 199m, 16.3167kn
Frequency (Hz) [2014-01-30 08:45:02]
3274, , CT_TANK, 243m, 12.0857kn
Frequency (Hz) [2014-01-28 13:30:01]
3274, , CT_CARGO, 260m, 16.4167kn
Frequency (Hz) [2014-01-22 01:45:01]
3274, , CT_CARGO, 188m, 15.1kn
Frequency (Hz) [2014-02-21 07:00:02]
3274, , CT_CARGO, 260m, 15.3167kn
Frequency (Hz) [2014-02-19 00:15:01]
3274, , CT_CARGO, 100m, 12.35kn
Frequency (Hz) [2014-02-17 07:30:01]
3274, , CT_TANK, 243m, 14.8714kn
Frequency (Hz) [2014-02-07 03:45:01]
dB re 1 μPa²/Hz @ 1m


3274, , CT_CARGO, 100m, 12.7kn
Frequency (Hz) [2014-02-22 00:00:01]
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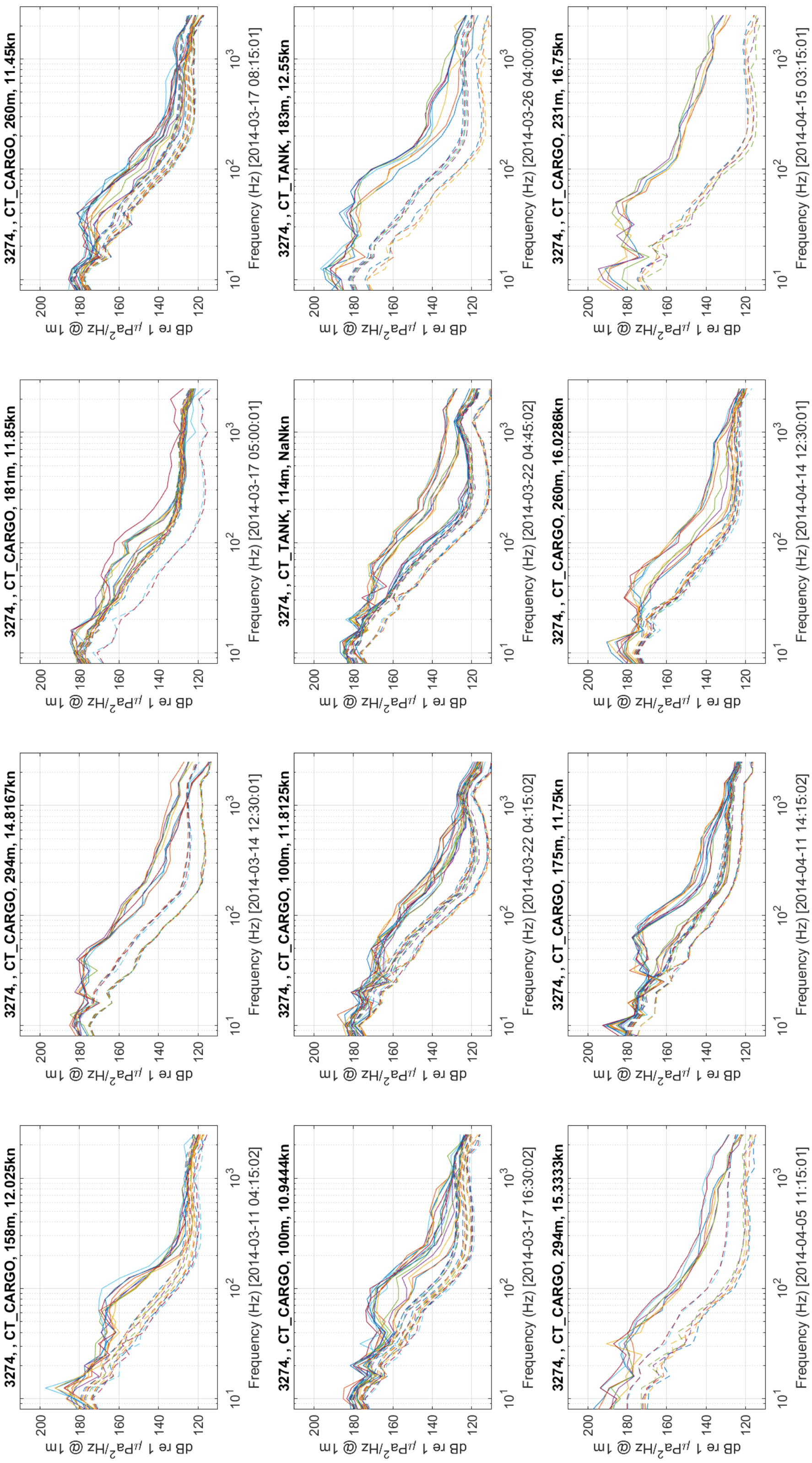
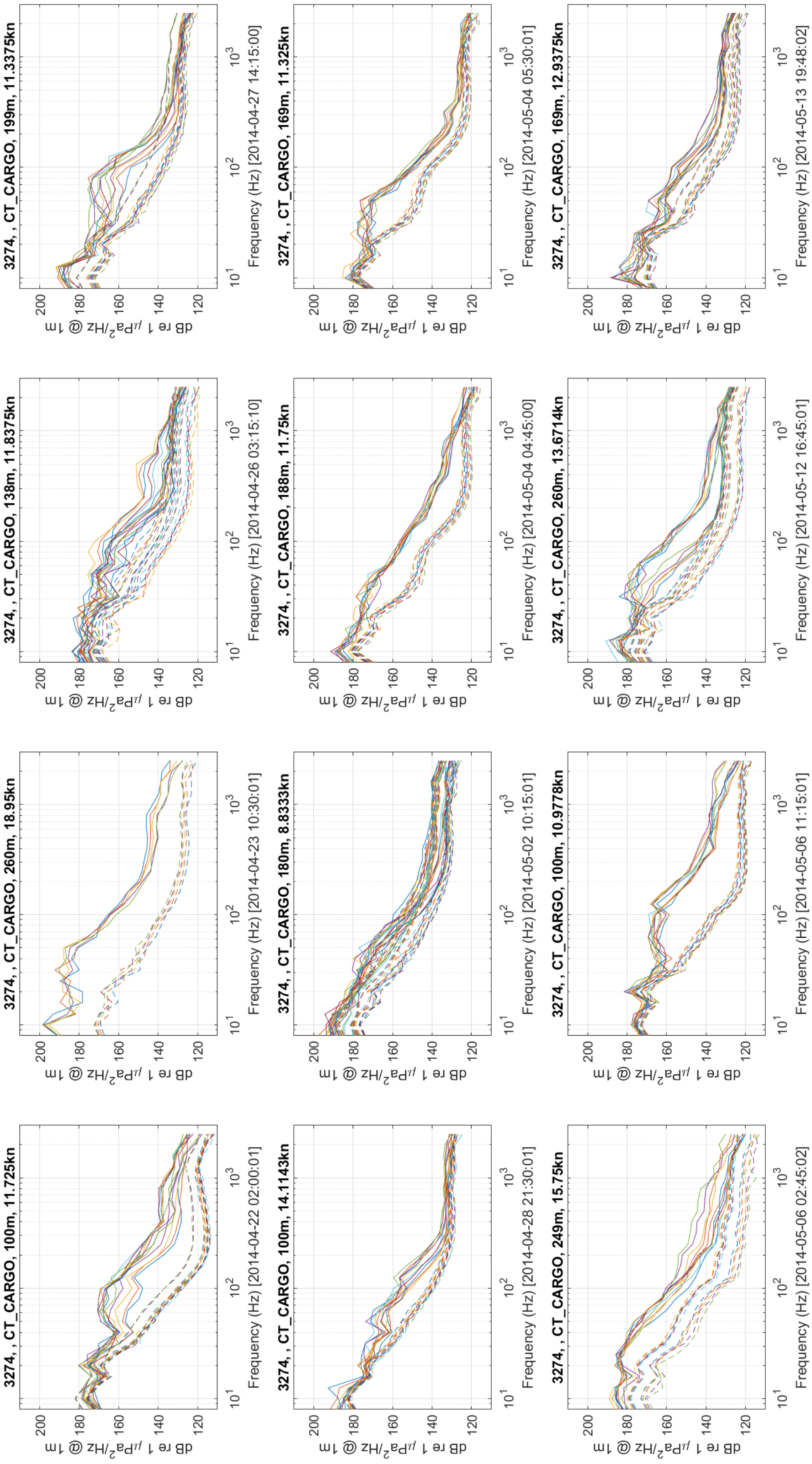
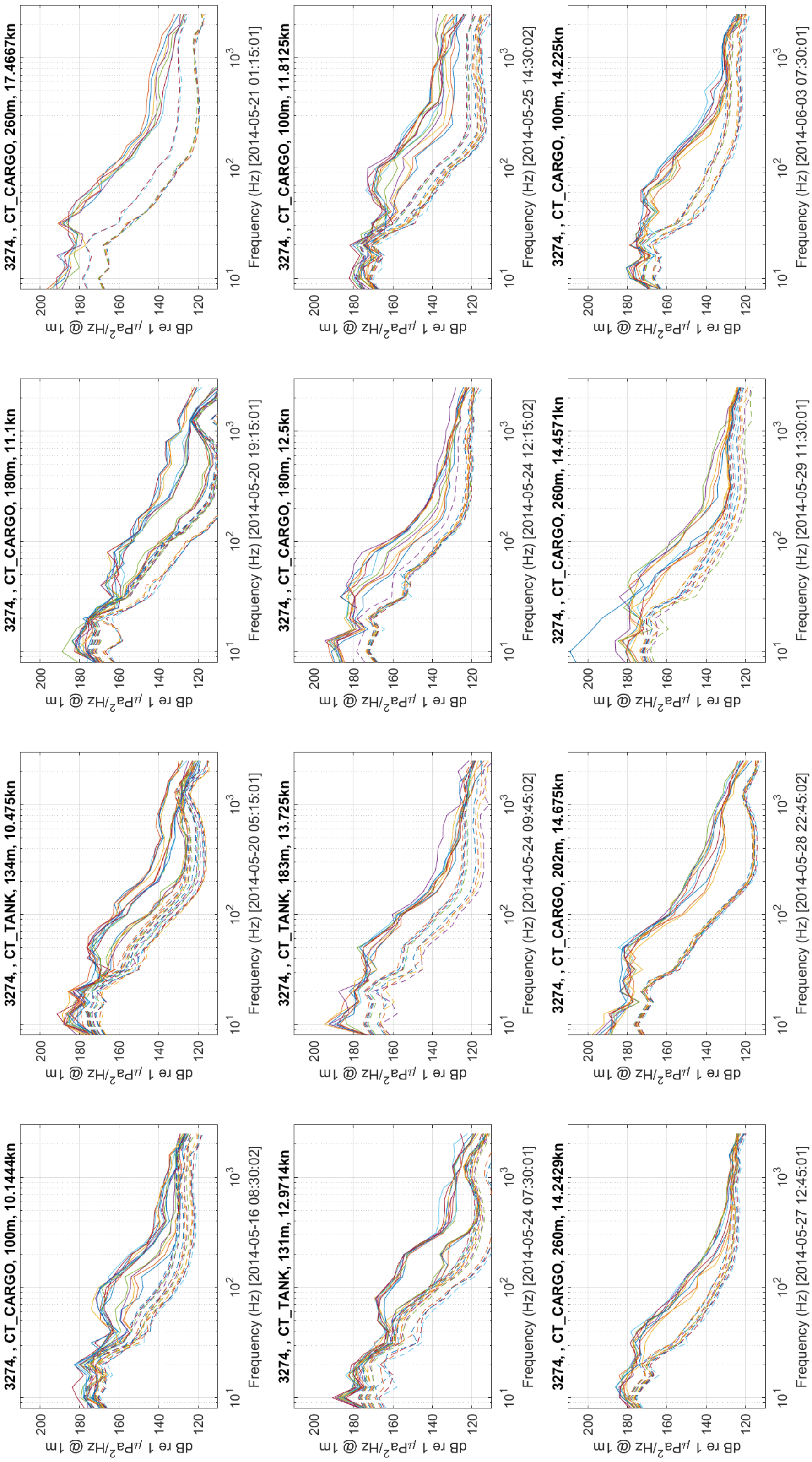
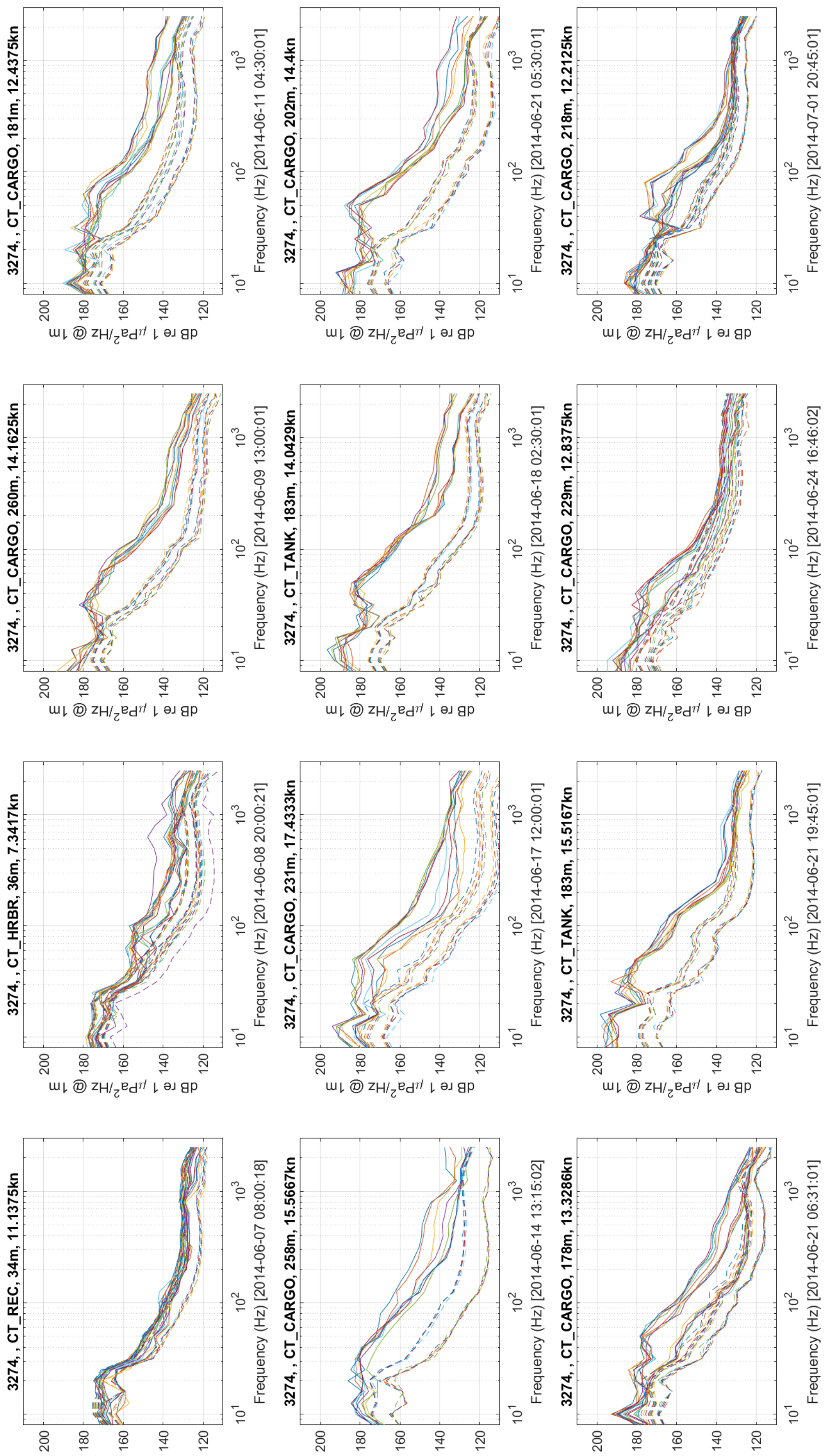
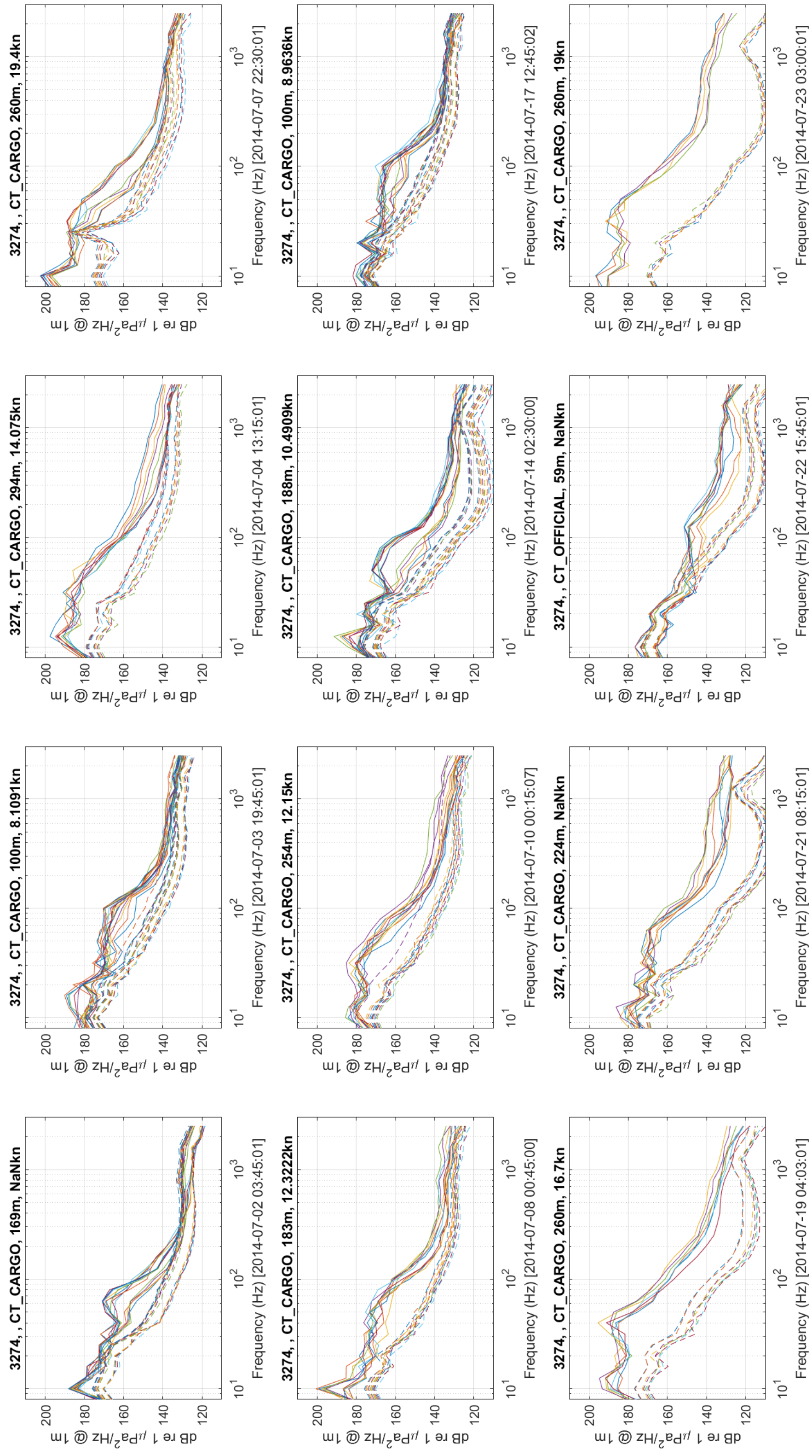
Frequency (Hz) [2014-02-22 13:45:01]
3274, , CT_CARGO, 179m, 13.4125kn
Frequency (Hz) [2014-02-23 04:30:01]
3274, , CT_CARGO, 231m, 16.2kn
Frequency (Hz) [2014-02-25 15:45:01]
3274, , CT_CARGO, 260m, 15.7kn
Frequency (Hz) [2014-02-26 19:15:01]
3274, , CT_CARGO, 100m, 12.7375kn
Frequency (Hz) [2014-03-01 22:45:01]
3274, , CT_TANK, 243m, 11.6kn
Frequency (Hz) [2014-03-02 11:00:02]
3274, , CT_CARGO, 190m, 13.1875kn
Frequency (Hz) [2014-03-05 04:30:01]
3274, , CT_CARGO, 100m, 12.4375kn
Frequency (Hz) [2014-03-06 23:01:01]
3274, , CT_TANK, 122m, 12.1375kn
Frequency (Hz) [2014-03-07 06:46:01]
3274, , CT_TANK, 243m, 9.62kn
Frequency (Hz) [2014-03-07 09:00:02]
3274, , CT_CARGO, 169m, 13.125kn
Frequency (Hz) [2014-03-10 02:15:01]
dB re 1 μPa²/Hz @ 1m

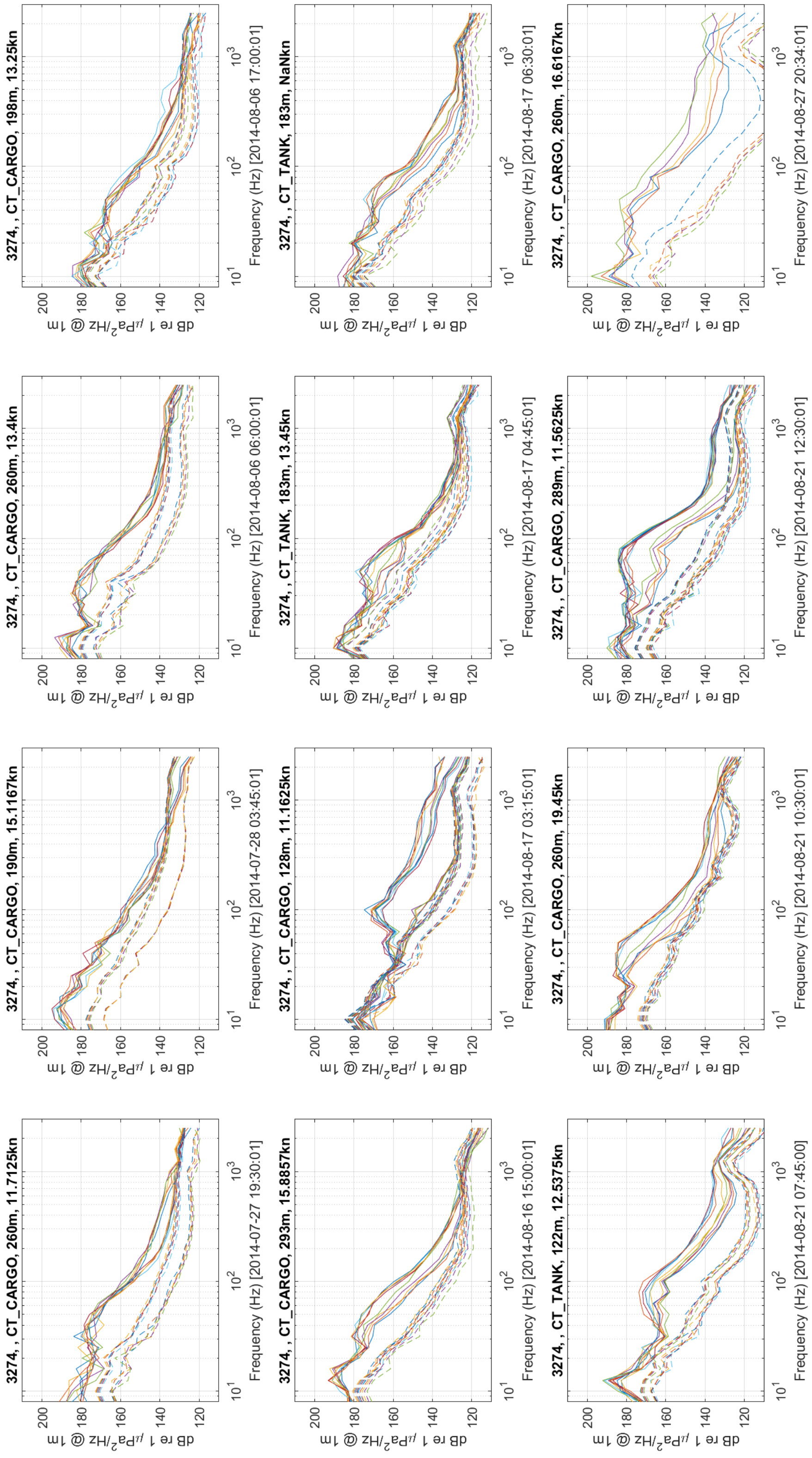

3274, , CT_CARGO, 158m, 12.025kn
Frequency (Hz) [2014-03-11 04:15:02]
3274, , CT_CARGO, 294m, 14.8167kn
Frequency (Hz) [2014-03-14 12:30:01]
3274, , CT_CARGO, 181m, 11.85kn
Frequency (Hz) [2014-03-17 05:00:01]
3274, , CT_CARGO, 260m, 11.45kn
Frequency (Hz) [2014-03-17 08:15:01]
3274, , CT_CARGO, 100m, 10.9444kn
Frequency (Hz) [2014-03-17 16:30:02]
3274, , CT_CARGO, 100m, 11.8125kn
Frequency (Hz) [2014-03-22 04:15:02]
3274, , CT_TANK, 114m, NaNkn
Frequency (Hz) [2014-03-22 04:45:02]
3274, , CT_TANK, 183m, 12.55kn
Frequency (Hz) [2014-03-26 04:00:00]
3274, , CT_CARGO, 294m, 15.3333kn
Frequency (Hz) [2014-04-05 11:15:01]
3274, , CT_CARGO, 175m, 11.75kn
Frequency (Hz) [2014-04-11 14:15:02]
3274, , CT_CARGO, 260m, 16.0286kn
Frequency (Hz) [2014-04-14 12:30:01]
3274, , CT_CARGO, 231m, 16.75kn
Frequency (Hz) [2014-04-15 03:15:01]
dB re 1 μPa²/Hz @ 1m

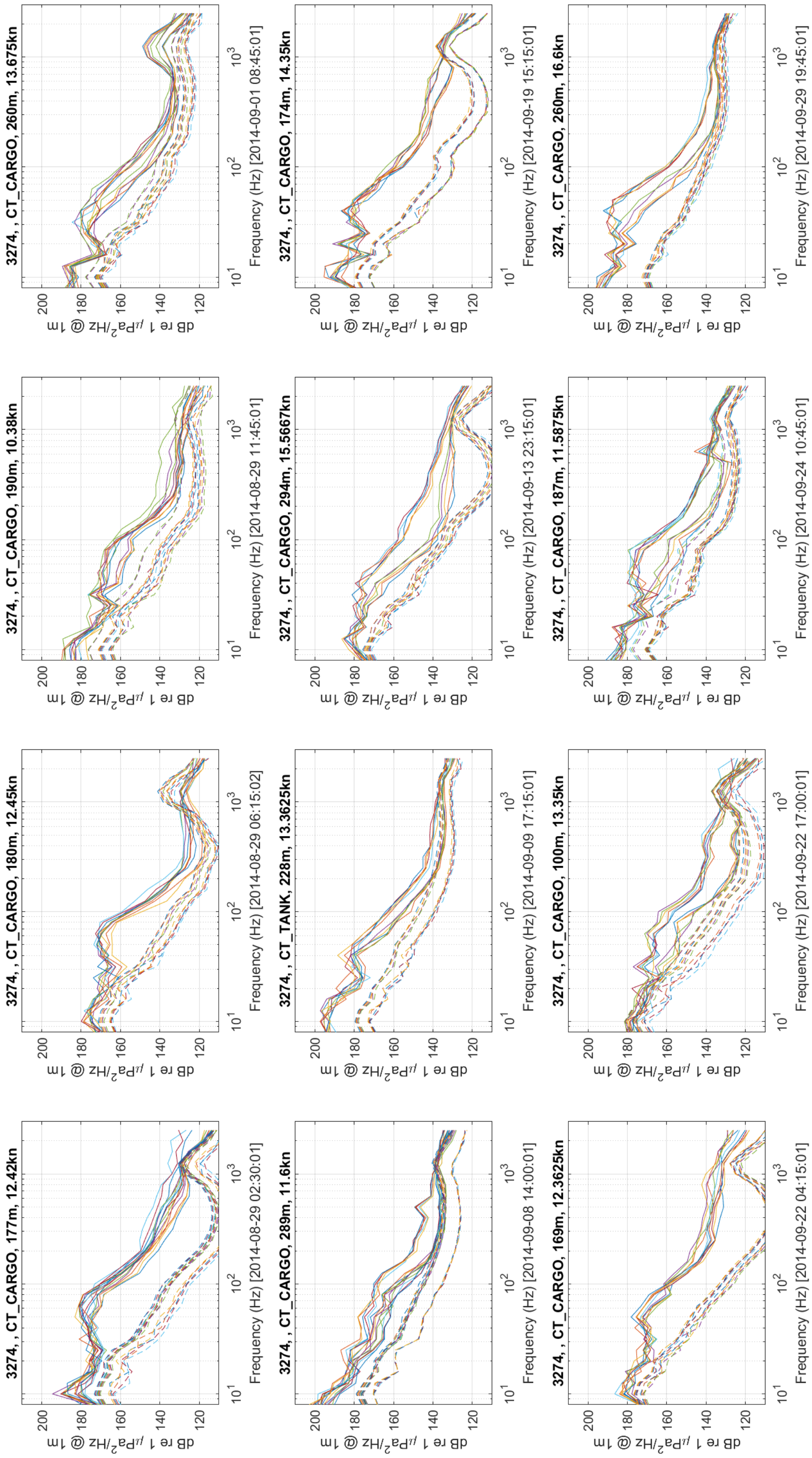

3274, , CT_CARGO, 199m, 11.3375kn
Frequency (Hz) [2014-04-27 14:15:00]
3274, , CT_CARGO, 169m, 11.325kn
Frequency (Hz) [2014-05-04 05:30:01]
3274, , CT_CARGO, 169m, 12.9375kn
Frequency (Hz) [2014-05-13 19:48:02]
3274, , CT_CARGO, 138m, 11.8375kn
Frequency (Hz) [2014-04-26 03:15:10]
3274, , CT_CARGO, 188m, 11.75kn
Frequency (Hz) [2014-05-04 04:45:00]
3274, , CT_CARGO, 260m, 13.6714kn
Frequency (Hz) [2014-05-12 16:45:01]
3274, , CT_CARGO, 260m, 18.95kn
Frequency (Hz) [2014-04-23 10:30:01]
3274, , CT_CARGO, 180m, 8.8333kn
Frequency (Hz) [2014-05-02 10:15:01]
3274, , CT_CARGO, 100m, 10.9778kn
Frequency (Hz) [2014-05-06 11:15:01]
3274, , CT_CARGO, 100m, 11.725kn
Frequency (Hz) [2014-04-22 02:00:01]
3274, , CT_CARGO, 100m, 14.1143kn
Frequency (Hz) [2014-04-28 21:30:01]
3274, , CT_CARGO, 249m, 15.75kn
Frequency (Hz) [2014-05-06 02:45:02]
dB re 1 μPa²/Hz @ 1m

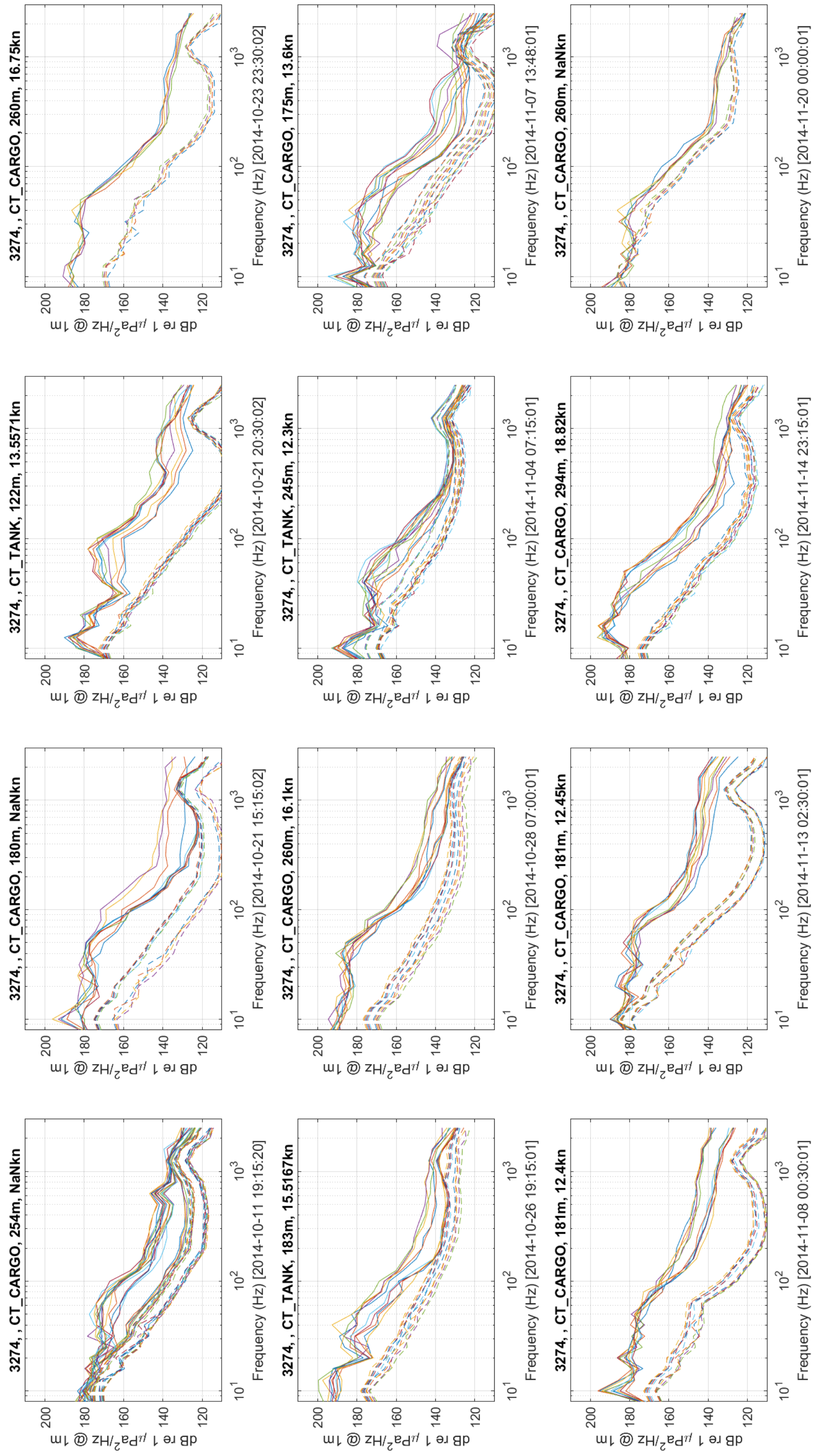

3274, , CT_CARGO, 100m, 10.1444kn
Frequency (Hz) [2014-05-16 08:30:02]
3274, , CT_TANK, 134m, 10.475kn
Frequency (Hz) [2014-05-20 05:15:01]
3274, , CT_CARGO, 180m, 11.1kn
Frequency (Hz) [2014-05-20 19:15:01]
3274, , CT_CARGO, 260m, 17.4667kn
Frequency (Hz) [2014-05-21 01:15:01]
3274, , CT_TANK, 131m, 12.9714kn
Frequency (Hz) [2014-05-24 07:30:01]
3274, , CT_TANK, 183m, 13.725kn
Frequency (Hz) [2014-05-24 09:45:02]
3274, , CT_CARGO, 180m, 12.5kn
Frequency (Hz) [2014-05-24 12:15:02]
3274, , CT_CARGO, 100m, 11.8125kn
Frequency (Hz) [2014-05-25 14:30:02]
3274, , CT_CARGO, 260m, 14.2429kn
Frequency (Hz) [2014-05-27 12:45:01]
3274, , CT_CARGO, 202m, 14.675kn
Frequency (Hz) [2014-05-28 22:45:02]
3274, , CT_CARGO, 260m, 14.4571kn
Frequency (Hz) [2014-05-29 11:30:01]
3274, , CT_CARGO, 100m, 14.225kn
Frequency (Hz) [2014-06-03 07:30:01]
dB re 1 μPa²/Hz @ 1m

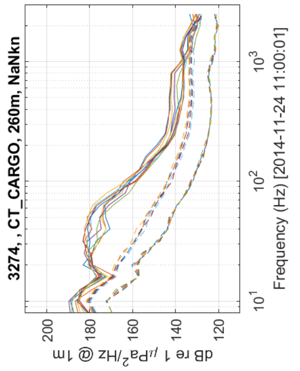

3274, , CT_REC, 34m, 11.1375kn
Frequency (Hz) [2014-06-07 08:00:18]
3274, , CT_HRBR, 36m, 7.3417kn
Frequency (Hz) [2014-06-08 20:00:21]
3274, , CT_CARGO, 260m, 14.1625kn
Frequency (Hz) [2014-06-09 13:00:01]
3274, , CT_CARGO, 181m, 12.4375kn
Frequency (Hz) [2014-06-11 04:30:01]
3274, , CT_CARGO, 258m, 15.5667kn
Frequency (Hz) [2014-06-14 13:15:02]
3274, , CT_CARGO, 231m, 17.4333kn
Frequency (Hz) [2014-06-17 12:00:01]
3274, , CT_TANK, 183m, 14.0429kn
Frequency (Hz) [2014-06-18 02:30:01]
3274, , CT_CARGO, 202m, 14.4kn
Frequency (Hz) [2014-06-21 05:30:01]
3274, , CT_CARGO, 178m, 13.3286kn
Frequency (Hz) [2014-06-21 06:31:01]
3274, , CT_TANK, 183m, 15.5167kn
Frequency (Hz) [2014-06-21 19:45:01]
3274, , CT_CARGO, 229m, 12.8375kn
Frequency (Hz) [2014-06-24 16:46:02]
3274, , CT_CARGO, 218m, 12.2125kn
Frequency (Hz) [2014-07-01 20:45:01]
dB re 1 μPa²/Hz @ 1m

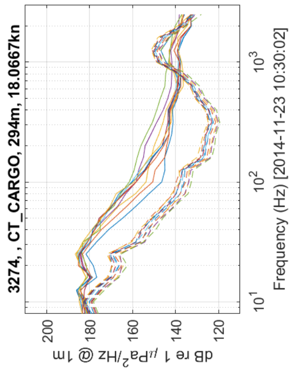

3274, , CT_CARGO, 169m, NaNkn
Frequency (Hz) [2014-07-02 03:45:01]
3274, , CT_CARGO, 100m, 8.1091kn
Frequency (Hz) [2014-07-03 19:45:01]
3274, , CT_CARGO, 294m, 14.075kn
Frequency (Hz) [2014-07-04 13:15:01]
3274, , CT_CARGO, 260m, 19.4kn
Frequency (Hz) [2014-07-07 22:30:01]
3274, , CT_CARGO, 183m, 12.3222kn
Frequency (Hz) [2014-07-08 00:45:00]
3274, , CT_CARGO, 254m, 12.15kn
Frequency (Hz) [2014-07-10 00:15:07]
3274, , CT_CARGO, 188m, 10.4909kn
Frequency (Hz) [2014-07-14 02:30:00]
3274, , CT_CARGO, 100m, 8.9636kn
Frequency (Hz) [2014-07-17 12:45:02]
3274, , CT_CARGO, 260m, 16.7kn
Frequency (Hz) [2014-07-19 04:03:01]
3274, , CT_CARGO, 224m, NaNkn
Frequency (Hz) [2014-07-21 08:15:01]
3274, , CT_OFFICIAL, 59m, NaNkn
Frequency (Hz) [2014-07-22 15:45:01]
3274, , CT_CARGO, 260m, 19kn
Frequency (Hz) [2014-07-23 03:00:01]
dB re 1 μPa²/Hz @ 1m

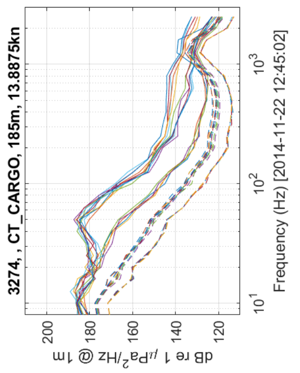

3274, , CT_CARGO, 198m, 13.25kn
Frequency (Hz) [2014-08-06 17:00:01]
3274, , CT_TANK, 183m, NaNkn
Frequency (Hz) [2014-08-17 06:30:01]
3274, , CT_CARGO, 260m, 16.6167kn
Frequency (Hz) [2014-08-27 20:34:01]
3274, , CT_CARGO, 260m, 13.4kn
Frequency (Hz) [2014-08-06 06:00:01]
3274, , CT_TANK, 183m, 13.45kn
Frequency (Hz) [2014-08-17 04:45:01]
3274, , CT_CARGO, 289m, 11.5625kn
Frequency (Hz) [2014-08-21 12:30:01]
3274, , CT_CARGO, 190m, 15.1167kn
Frequency (Hz) [2014-07-28 03:45:01]
3274, , CT_CARGO, 128m, 11.1625kn
Frequency (Hz) [2014-08-17 03:15:01]
3274, , CT_CARGO, 260m, 19.45kn
Frequency (Hz) [2014-08-21 10:30:01]
3274, , CT_CARGO, 260m, 11.7125kn
Frequency (Hz) [2014-07-27 19:30:01]
3274, , CT_CARGO, 293m, 15.8857kn
Frequency (Hz) [2014-08-16 15:00:01]
3274, , CT_TANK, 122m, 12.5375kn
Frequency (Hz) [2014-08-21 07:45:00]
dB re 1 μPa²/Hz @ 1m

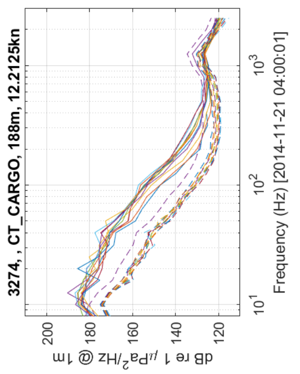

3274, , CT_CARGO, 260m, 13.675kn
Frequency (Hz) [2014-09-01 08:45:01]
3274, , CT_CARGO, 174m, 14.35kn
Frequency (Hz) [2014-09-19 15:15:01]
3274, , CT_CARGO, 260m, 16.6kn
Frequency (Hz) [2014-09-29 19:45:01]
3274, , CT_CARGO, 190m, 10.38kn
Frequency (Hz) [2014-08-29 11:45:01]
3274, , CT_CARGO, 294m, 15.5667kn
Frequency (Hz) [2014-09-13 23:15:01]
3274, , CT_CARGO, 187m, 11.5875kn
Frequency (Hz) [2014-09-24 10:45:01]
3274, , CT_CARGO, 180m, 12.45kn
Frequency (Hz) [2014-08-29 06:15:02]
3274, , CT_TANK, 228m, 13.3625kn
Frequency (Hz) [2014-09-09 17:15:01]
3274, , CT_CARGO, 100m, 13.35kn
Frequency (Hz) [2014-09-22 17:00:01]
3274, , CT_CARGO, 177m, 12.42kn
Frequency (Hz) [2014-08-29 02:30:01]
3274, , CT_CARGO, 289m, 11.6kn
Frequency (Hz) [2014-09-08 14:00:01]
3274, , CT_CARGO, 169m, 12.3625kn
Frequency (Hz) [2014-09-22 04:15:01]
dB re 1 μPa²/Hz @ 1m

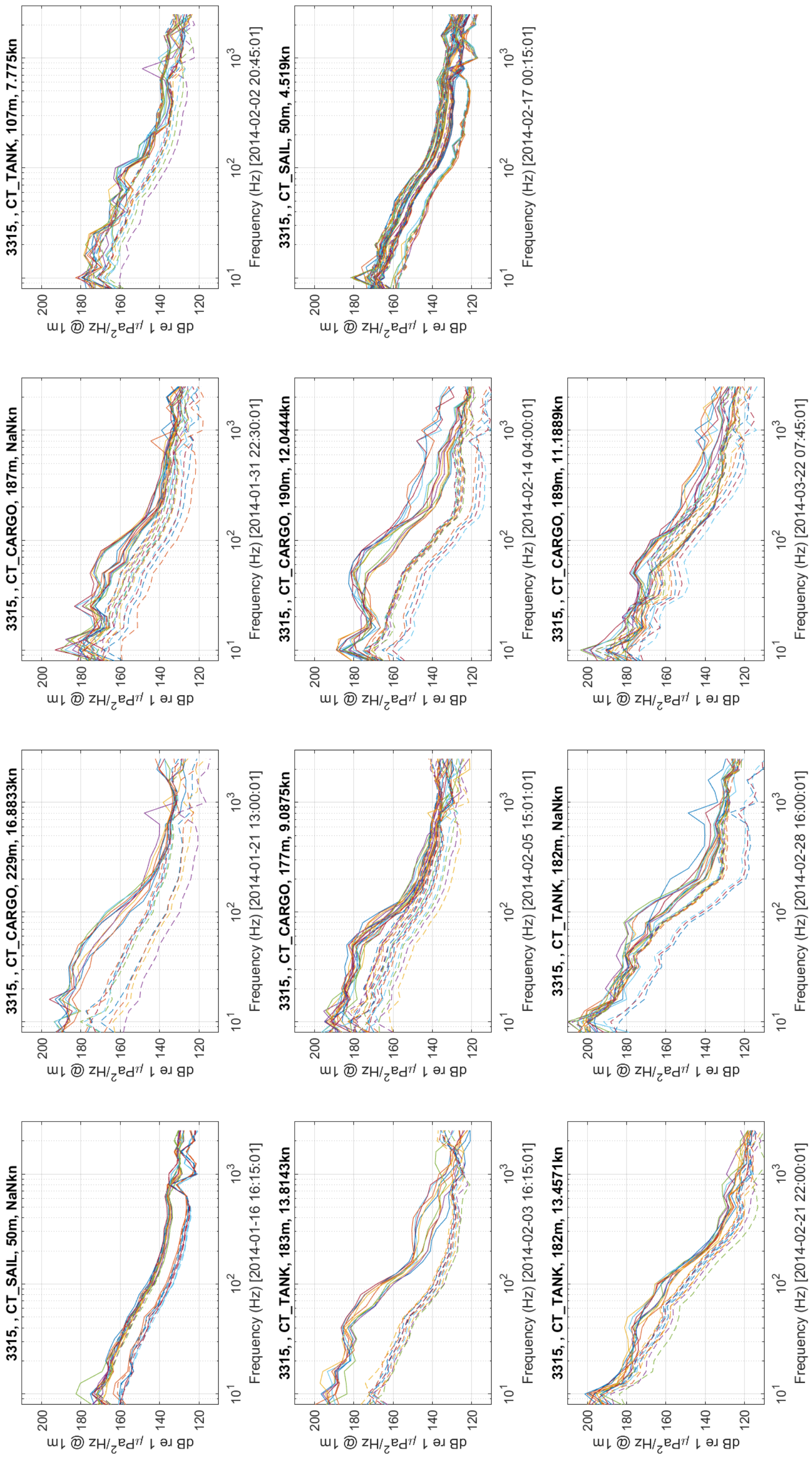

3274, , CT_CARGO, 254m, NaNkn
Frequency (Hz) [2014-10-11 19:15:20]
3274, , CT_CARGO, 180m, NaNkn
Frequency (Hz) [2014-10-21 15:15:02]
3274, , CT_TANK, 122m, 13.5571kn
Frequency (Hz) [2014-10-21 20:30:02]
3274, , CT_CARGO, 260m, 16.75kn
Frequency (Hz) [2014-10-23 23:30:02]
3274, , CT_TANK, 183m, 15.5167kn
Frequency (Hz) [2014-10-26 19:15:01]
3274, , CT_CARGO, 260m, 16.1kn
Frequency (Hz) [2014-10-28 07:00:01]
3274, , CT_TANK, 245m, 12.3kn
Frequency (Hz) [2014-11-04 07:15:01]
3274, , CT_CARGO, 175m, 13.6kn
Frequency (Hz) [2014-11-07 13:48:01]
3274, , CT_CARGO, 181m, 12.4kn
Frequency (Hz) [2014-11-08 00:30:01]
3274, , CT_CARGO, 181m, 12.45kn
Frequency (Hz) [2014-11-13 02:30:01]
3274, , CT_CARGO, 294m, 18.82kn
Frequency (Hz) [2014-11-14 23:15:01]
3274, , CT_CARGO, 260m, NaNkn
Frequency (Hz) [2014-11-20 00:00:01]
dB re 1 μPa²/Hz @ 1m

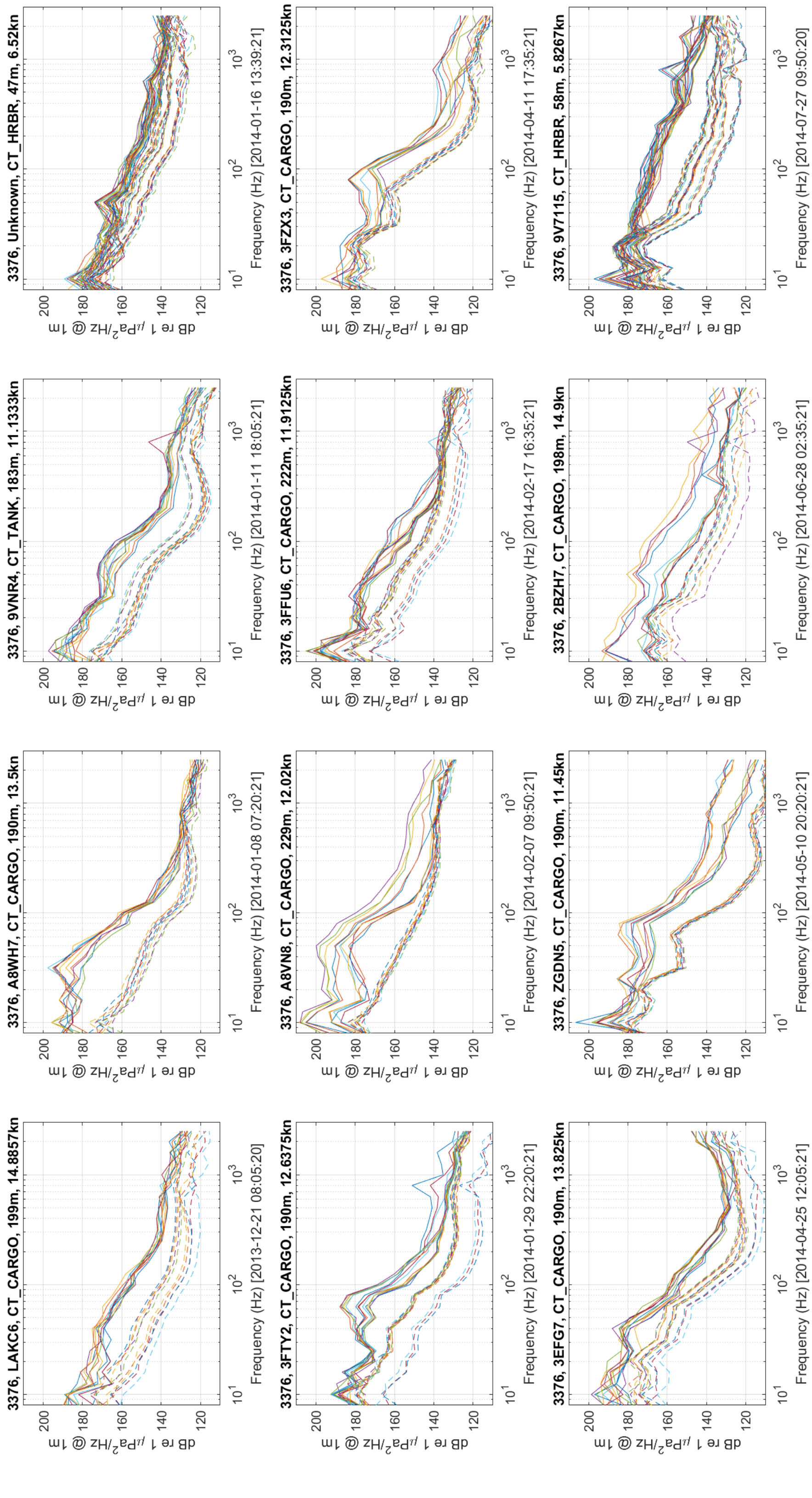

3274, , CT_CARGO, 260m, NaNkn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-24 11:00:01]

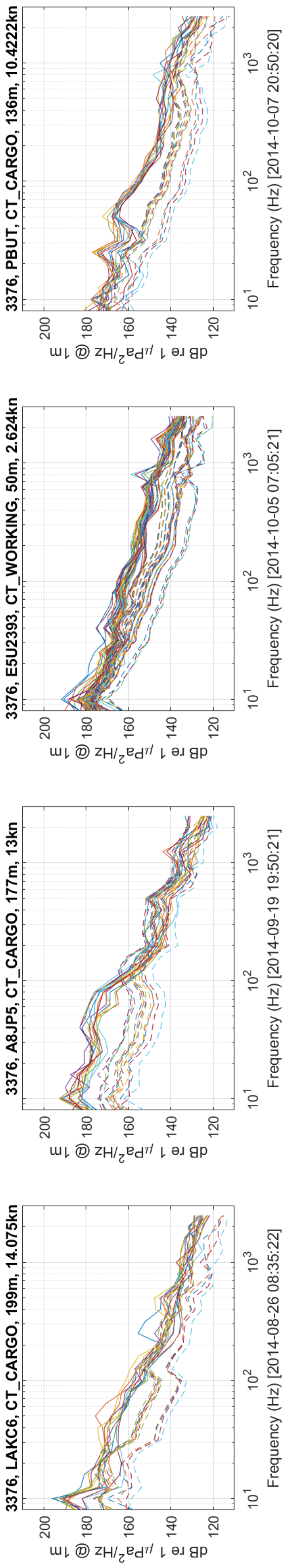

3274, , CT_CARGO, 294m, 18.0667kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-23 10:30:02]

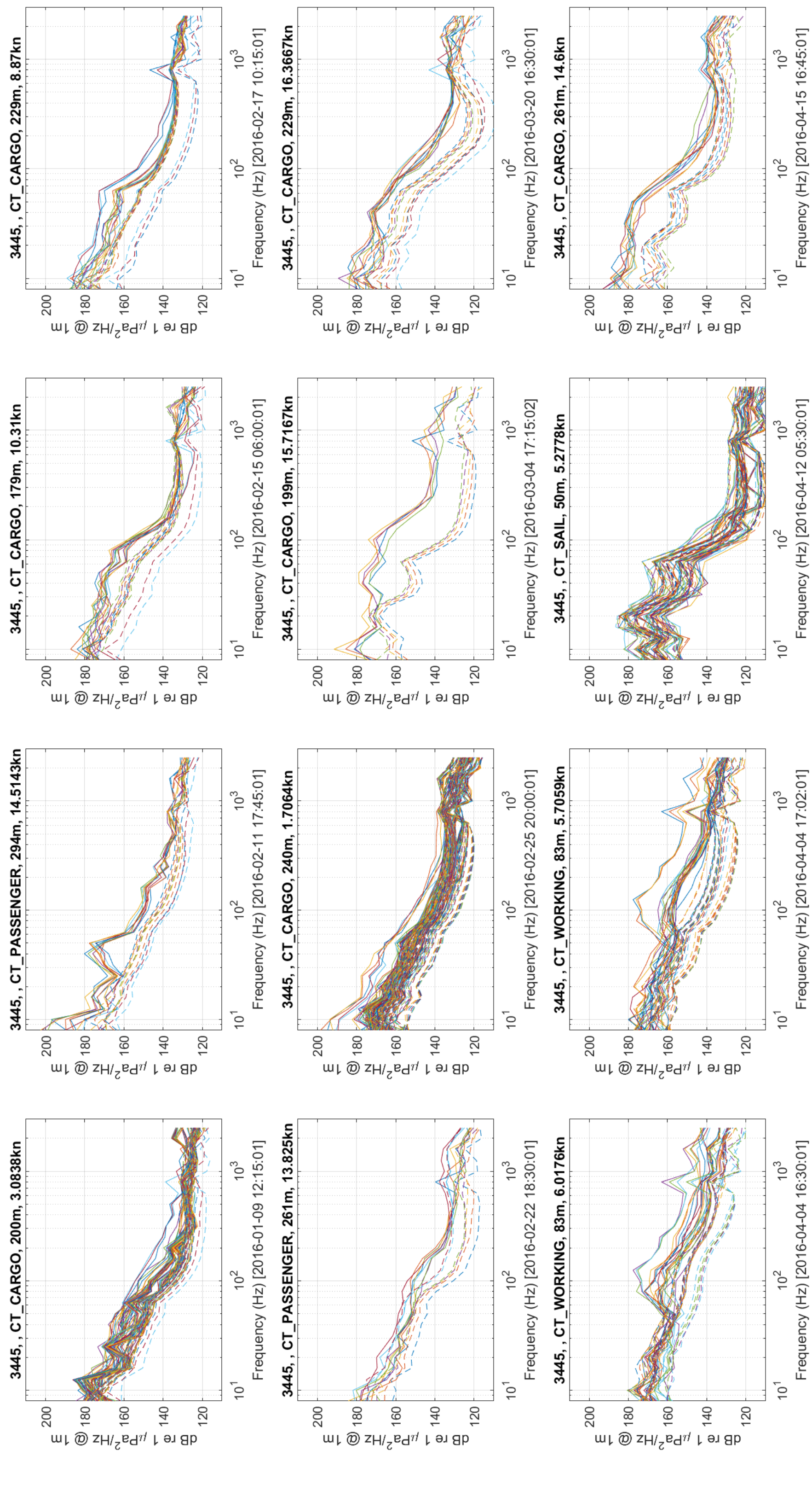

3274, , CT_CARGO, 185m, 13.8875kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-22 12:45:02]

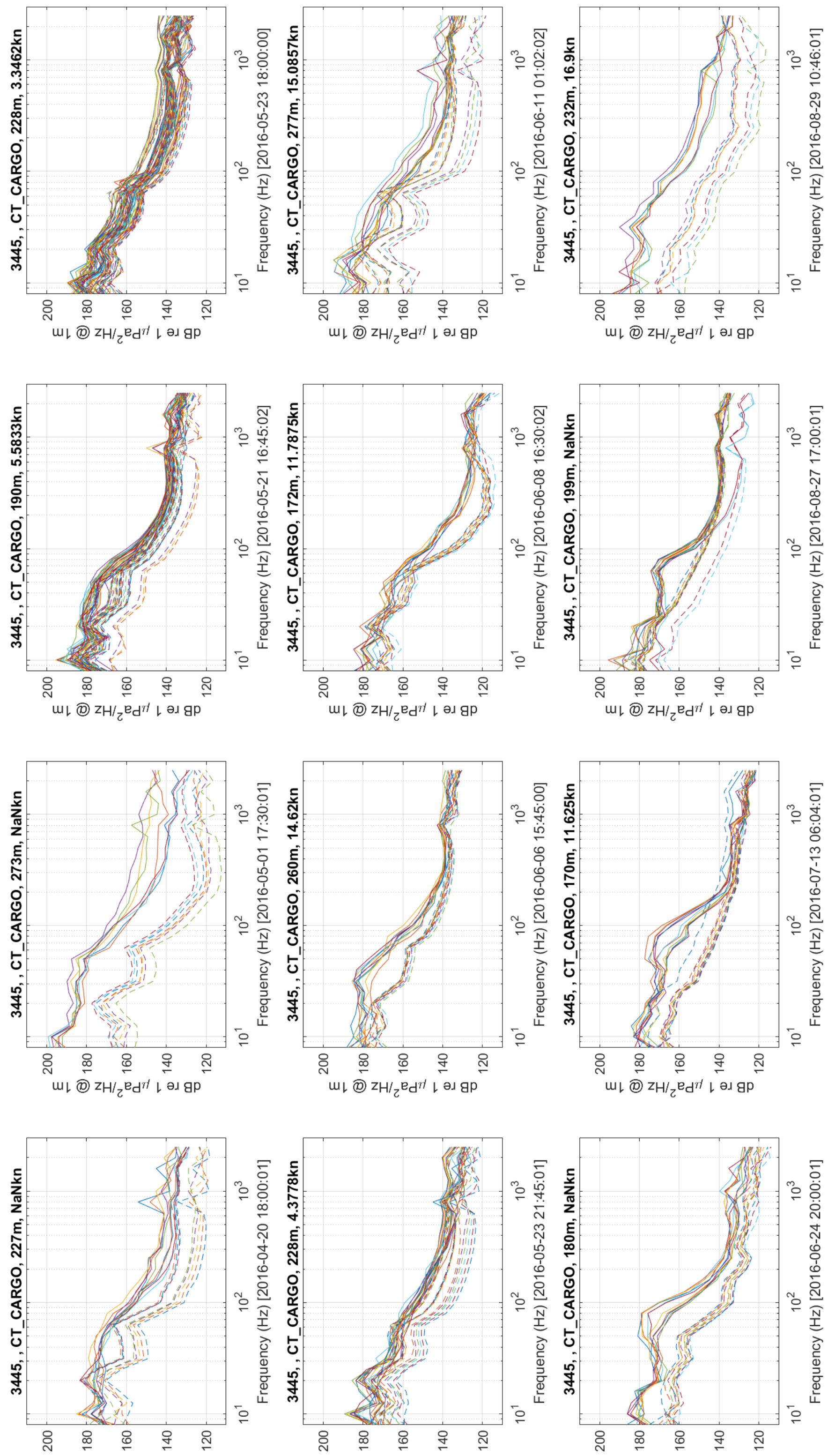

3274, , CT_CARGO, 188m, 12.2125kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-21 04:00:01]

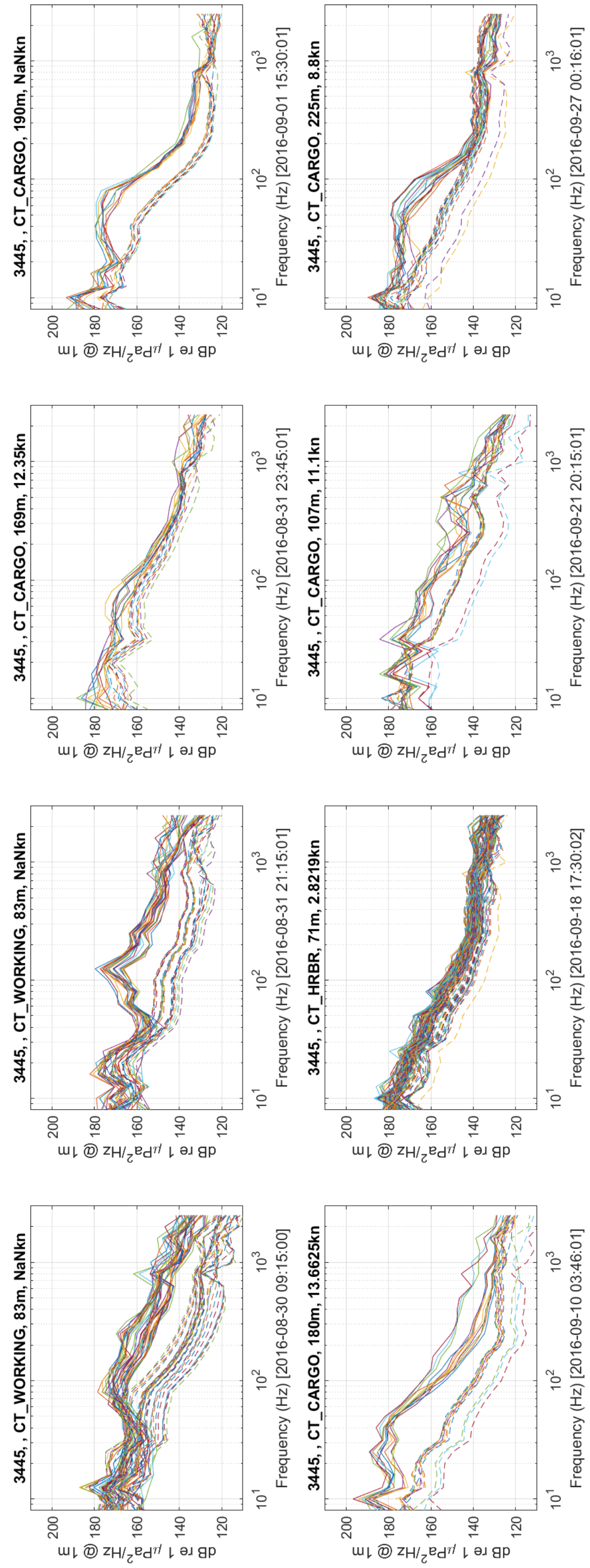

3315, , CT_TANK, 107m, 7.775kn
Frequency (Hz) [2014-02-02 20:45:01]
3315, , CT_SAIL, 50m, 4.519kn
Frequency (Hz) [2014-02-17 00:15:01]
3315, , CT_CARGO, 187m, NaNkn
Frequency (Hz) [2014-01-31 22:30:01]
3315, , CT_CARGO, 190m, 12.0444kn
Frequency (Hz) [2014-02-14 04:00:01]
3315, , CT_CARGO, 189m, 11.1889kn
Frequency (Hz) [2014-03-22 07:45:01]
3315, , CT_CARGO, 229m, 16.8833kn
Frequency (Hz) [2014-01-21 13:00:01]
3315, , CT_CARGO, 177m, 9.0875kn
Frequency (Hz) [2014-02-05 15:01:01]
3315, , CT_TANK, 182m, NaNkn
Frequency (Hz) [2014-02-28 16:00:01]
3315, , CT_SAIL, 50m, NaNkn
Frequency (Hz) [2014-01-16 16:15:01]
3315, , CT_TANK, 183m, 13.8143kn
Frequency (Hz) [2014-02-03 16:15:01]
3315, , CT_TANK, 182m, 13.4571kn
Frequency (Hz) [2014-02-21 22:00:01]
dB re 1 μPa²/Hz @ 1m


3376, Unknown, CT_HRBR, 47m, 6.52kn
Frequency (Hz) [2014-01-16 13:39:21]
3376, 3FZX3, CT_CARGO, 190m, 12.3125kn
Frequency (Hz) [2014-04-11 17:35:21]
3376, 9V7115, CT_HRBR, 58m, 5.8267kn
Frequency (Hz) [2014-07-27 09:50:20]
3376, 9VNR4, CT_TANK, 183m, 11.1333kn
Frequency (Hz) [2014-01-11 18:05:21]
3376, 3FFU6, CT_CARGO, 222m, 11.9125kn
Frequency (Hz) [2014-02-17 16:35:21]
3376, 2BZH7, CT_CARGO, 198m, 14.9kn
Frequency (Hz) [2014-06-28 02:35:21]
3376, A8WH7, CT_CARGO, 190m, 13.5kn
Frequency (Hz) [2014-01-08 07:20:21]
3376, A8VN8, CT_CARGO, 229m, 12.02kn
Frequency (Hz) [2014-02-07 09:50:21]
3376, ZGDN5, CT_CARGO, 190m, 11.45kn
Frequency (Hz) [2014-05-10 20:20:21]
3376, LAKC6, CT_CARGO, 199m, 14.8857kn
Frequency (Hz) [2013-12-21 08:05:20]
3376, 3FTY2, CT_CARGO, 190m, 12.6375kn
Frequency (Hz) [2014-01-29 22:20:21]
3376, 3EFG7, CT_CARGO, 190m, 13.825kn
Frequency (Hz) [2014-04-25 12:05:21]
dB re 1 μPa²/Hz @ 1m


3376, PBUT, CT_CARGO, 136m, 10.4222kn
Frequency (Hz) [2014-10-07 20:50:20]
3376, E5U2393, CT_WORKING, 50m, 2.624kn
Frequency (Hz) [2014-10-05 07:05:21]
3376, A8JP5, CT_CARGO, 177m, 13kn
Frequency (Hz) [2014-09-19 19:50:21]
3376, LAKC6, CT_CARGO, 199m, 14.075kn
Frequency (Hz) [2014-08-26 08:35:22]
dB re 1 μPa²/Hz @ 1m

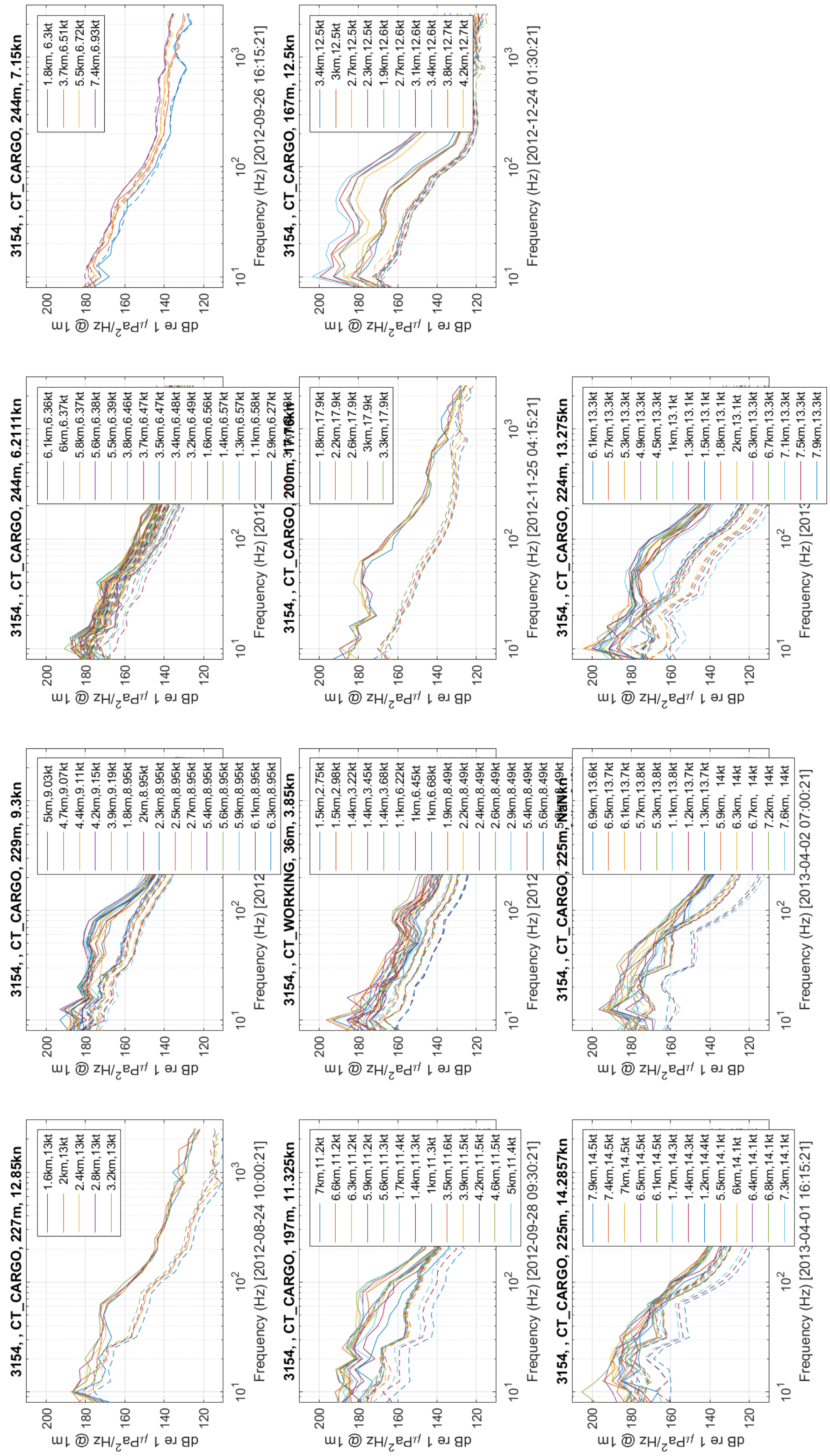

3445, , CT_CARGO, 229m, 8.87kn
Frequency (Hz) [2016-02-17 10:15:01]
3445, , CT_CARGO, 229m, 16.3667kn
Frequency (Hz) [2016-03-20 16:30:01]
3445, , CT_CARGO, 261m, 14.6kn
Frequency (Hz) [2016-04-15 16:45:01]
3445, , CT_CARGO, 179m, 10.31kn
Frequency (Hz) [2016-02-15 06:00:01]
3445, , CT_CARGO, 199m, 15.7167kn
Frequency (Hz) [2016-03-04 17:15:02]
3445, , CT_SAIL, 50m, 5.2778kn
Frequency (Hz) [2016-04-12 05:30:01]
3445, , CT_PASSENGER, 294m, 14.5143kn
Frequency (Hz) [2016-02-11 17:45:01]
3445, , CT_CARGO, 240m, 1.7064kn
Frequency (Hz) [2016-02-25 20:00:01]
3445, , CT_WORKING, 83m, 5.7059kn
Frequency (Hz) [2016-04-04 17:02:01]
3445, , CT_CARGO, 200m, 3.0838kn
Frequency (Hz) [2016-01-09 12:15:01]
3445, , CT_PASSENGER, 261m, 13.825kn
Frequency (Hz) [2016-02-22 18:30:01]
3445, , CT_WORKING, 83m, 6.0176kn
Frequency (Hz) [2016-04-04 16:30:01]
dB re 1 μPa²/Hz @ 1m

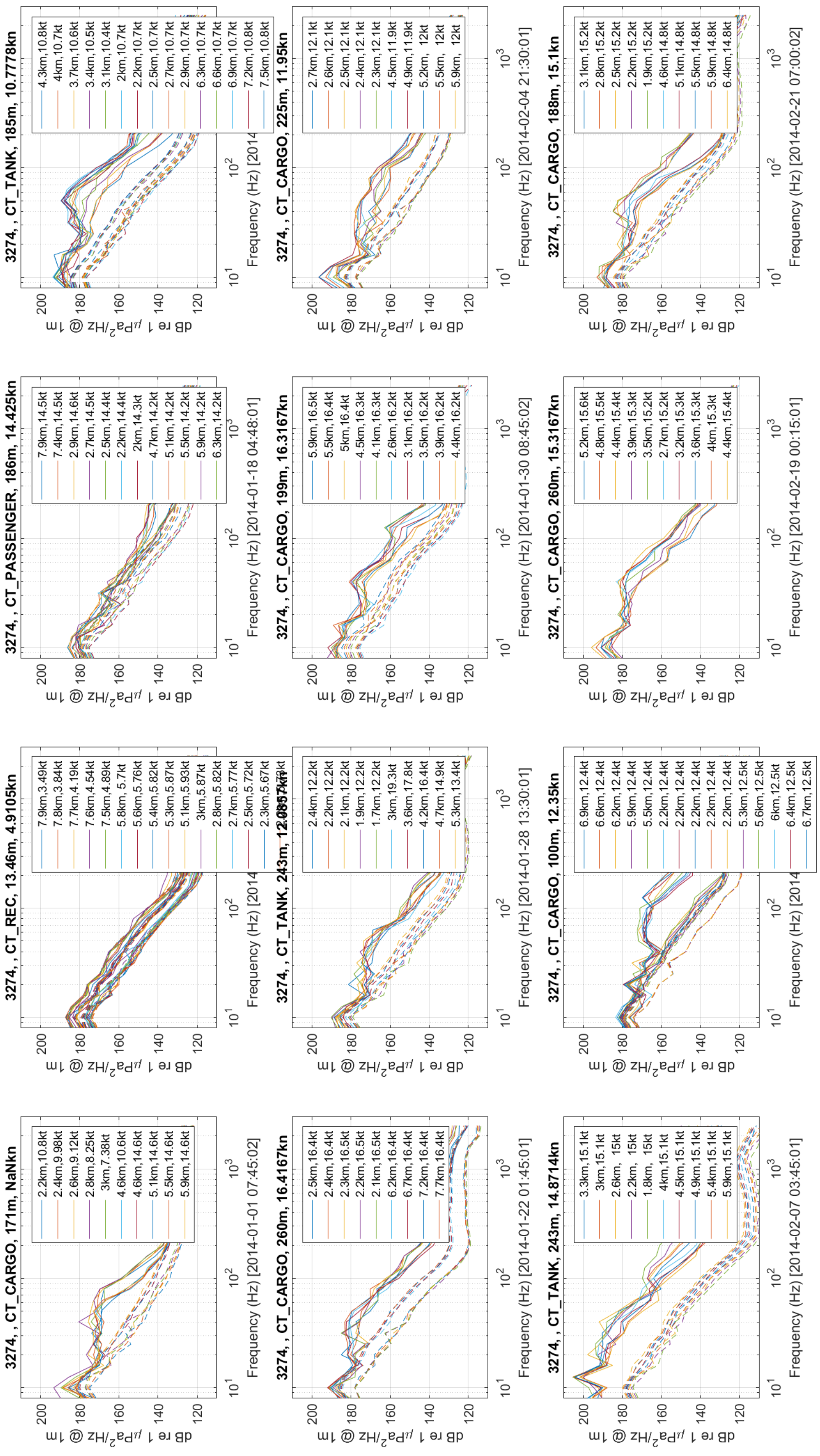

3445, , CT_CARGO, 228m, 3.3462kn
Frequency (Hz) [2016-05-23 18:00:00]
3445, , CT_CARGO, 277m, 15.0857kn
Frequency (Hz) [2016-06-11 01:02:02]
3445, , CT_CARGO, 232m, 16.9kn
Frequency (Hz) [2016-08-29 10:46:01]
3445, , CT_CARGO, 190m, 5.5833kn
Frequency (Hz) [2016-05-21 16:45:02]
3445, , CT_CARGO, 172m, 11.7875kn
Frequency (Hz) [2016-06-08 16:30:02]
3445, , CT_CARGO, 199m, NaNkn
Frequency (Hz) [2016-08-27 17:00:01]
3445, , CT_CARGO, 273m, NaNkn
Frequency (Hz) [2016-05-01 17:30:01]
3445, , CT_CARGO, 260m, 14.62kn
Frequency (Hz) [2016-06-06 15:45:00]
3445, , CT_CARGO, 170m, 11.625kn
Frequency (Hz) [2016-07-13 06:04:01]
3445, , CT_CARGO, 227m, NaNkn
Frequency (Hz) [2016-04-20 18:00:01]
3445, , CT_CARGO, 228m, 4.3778kn
Frequency (Hz) [2016-05-23 21:45:01]
3445, , CT_CARGO, 180m, NaNkn
Frequency (Hz) [2016-06-24 20:00:01]
dB re 1 μPa²/Hz @ 1m

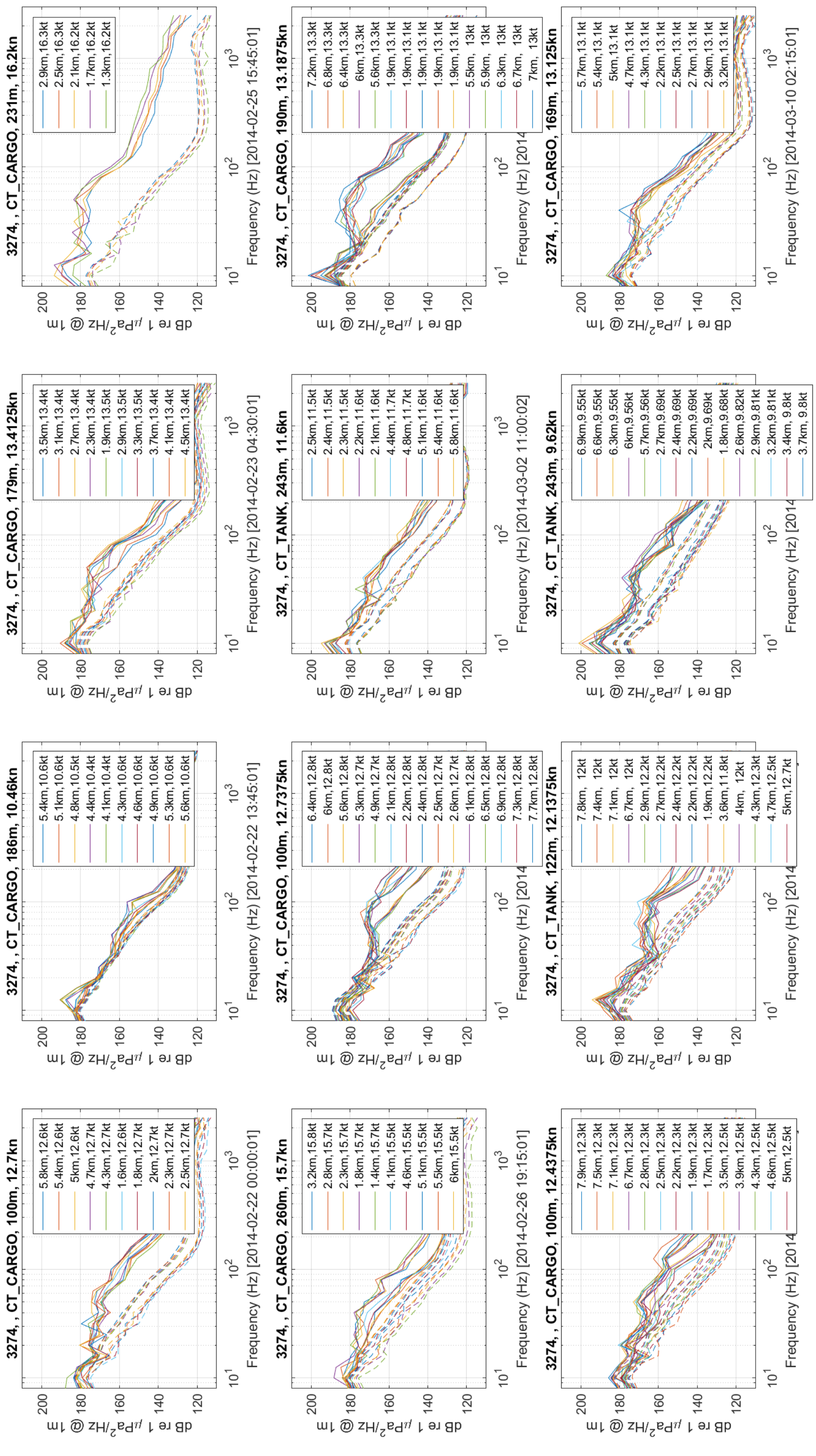

3445, , CT_CARGO, 190m, NaNkn
Frequency (Hz) [2016-09-01 15:30:01]
3445, , CT_CARGO, 225m, 8.8kn
Frequency (Hz) [2016-09-27 00:16:01]
3445, , CT_CARGO, 169m, 12.35kn
Frequency (Hz) [2016-08-31 23:45:01]
3445, , CT_CARGO, 107m, 11.1kn
Frequency (Hz) [2016-09-21 20:15:01]
3445, , CT_WORKING, 83m, NaNkn
Frequency (Hz) [2016-08-31 21:15:01]
3445, , CT_HRBR, 71m, 2.8219kn
Frequency (Hz) [2016-09-18 17:30:02]
3445, , CT_WORKING, 83m, NaNkn
Frequency (Hz) [2016-08-30 09:15:00]
3445, , CT_CARGO, 180m, 13.6625kn
Frequency (Hz) [2016-09-10 03:46:01]
dB re 1 μPa²/Hz @ 1m

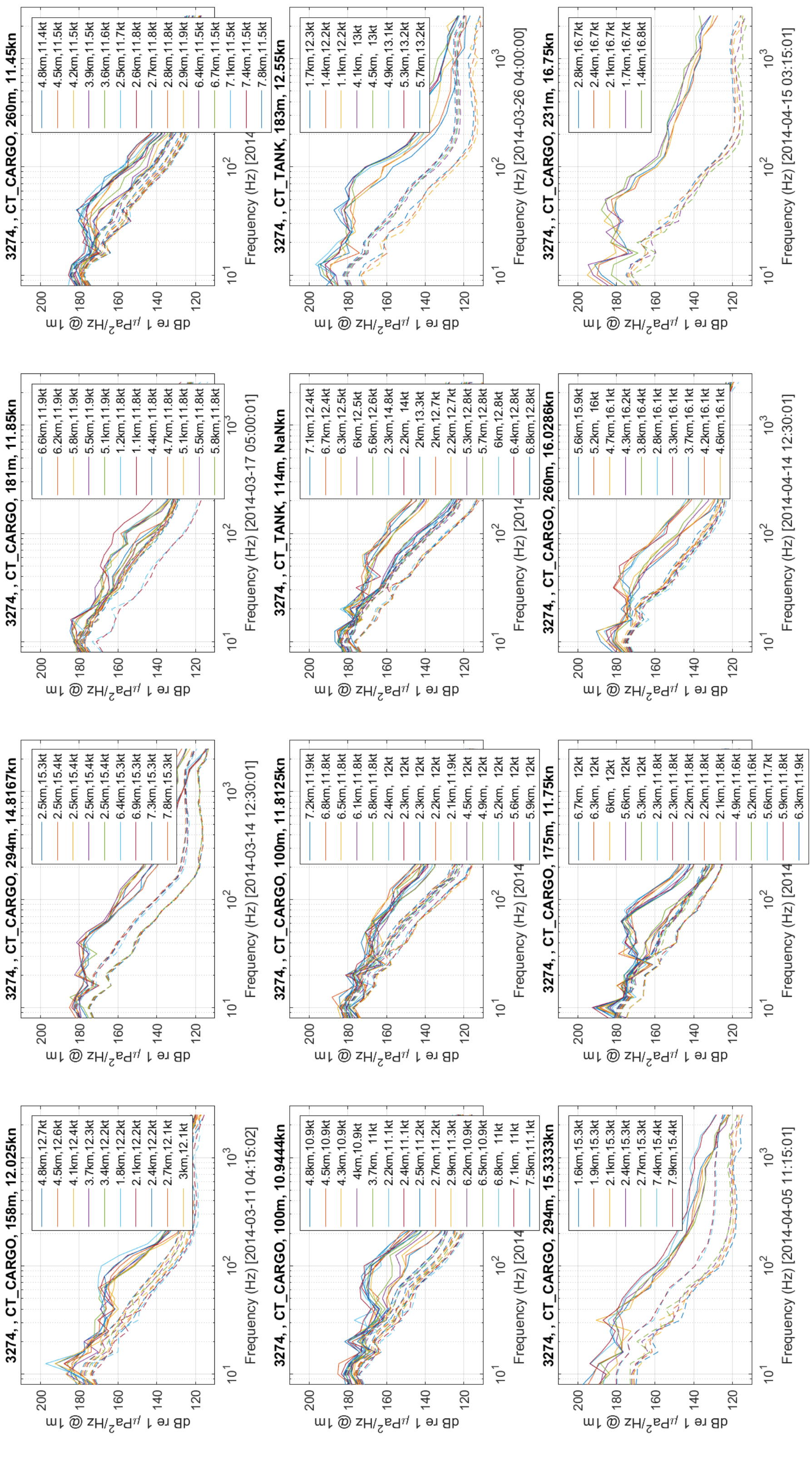
# APPENDIX B – SOURCE SPECTRA FROM INDIVIDUAL SHIP PASSES (WITH LEGENDS)

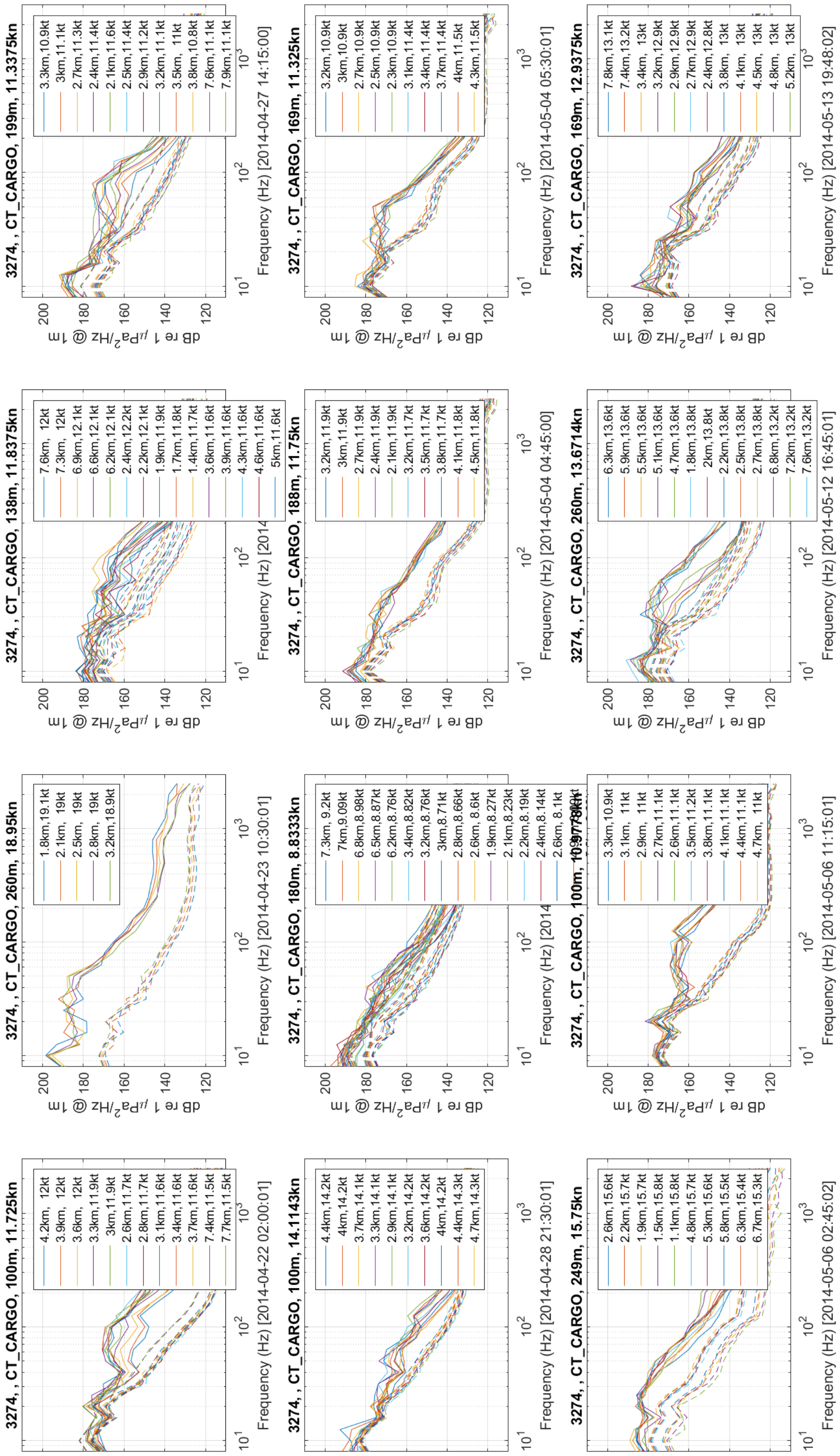
As for Appendix A, but including legends indicating the range (horizontal distance) of the ship from the recorder and vessel speed for each pass. NaN indicates no information available.

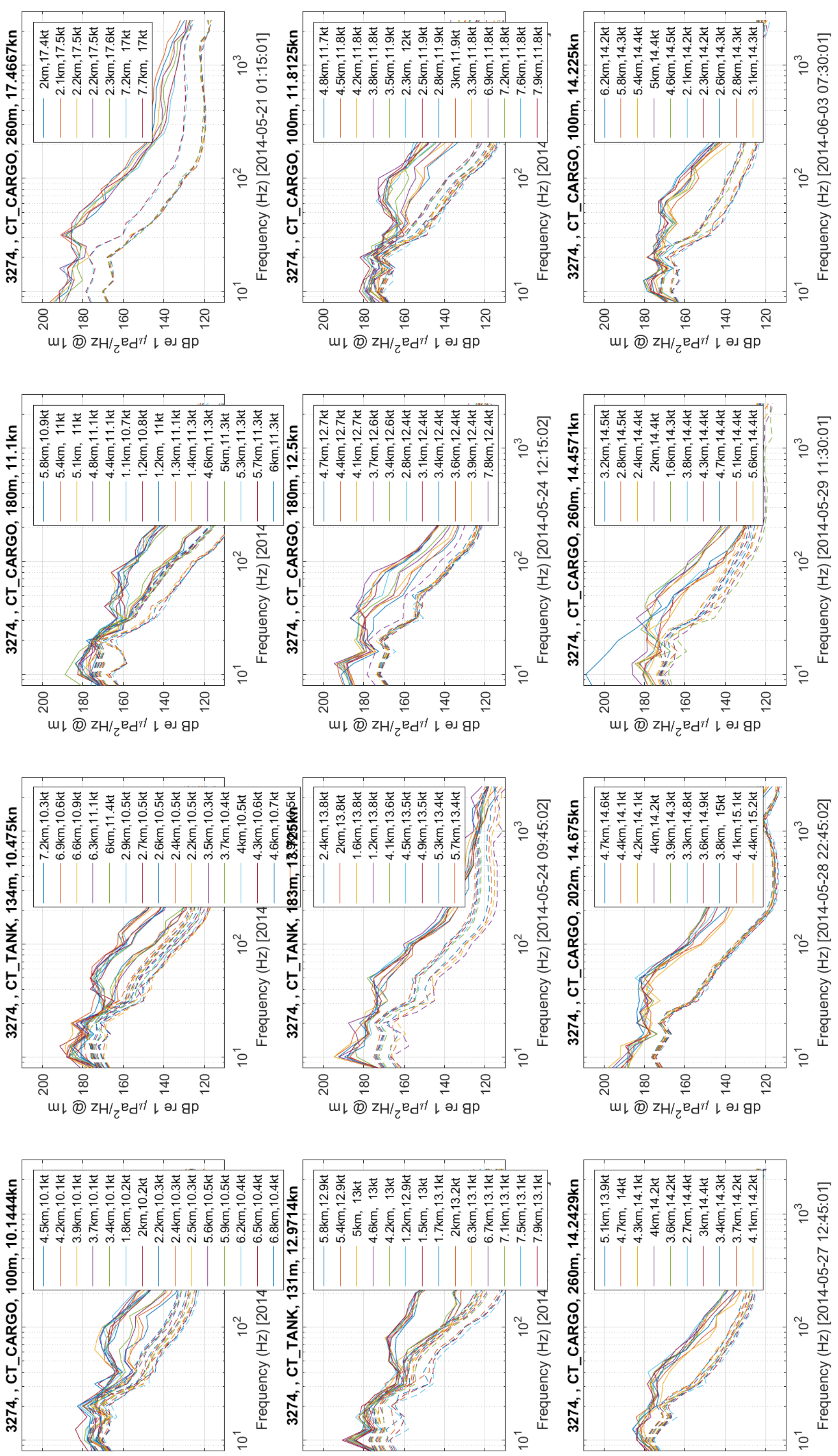

3154, , CT_CARGO, 244m, 7.15kn
Frequency (Hz) [2012-09-26 16:15:21]
3154, , CT_CARGO, 167m, 12.5kn
Frequency (Hz) [2012-12-24 01:30:21]
3154, , CT_CARGO, 244m, 6.2111kn
3154, , CT_CARGO, 200m, 17.9kn
Frequency (Hz) [2012-11-25 04:15:21]
3154, , CT_CARGO, 224m, 13.275kn
3154, , CT_CARGO, 229m, 9.3kn
3154, , CT_WORKING, 36m, 3.85kn
3154, , CT_CARGO, 225m
Frequency (Hz) [2013-04-02 07:00:21]
3154, , CT_CARGO, 227m, 12.85kn
Frequency (Hz) [2012-08-24 10:00:21]
3154, , CT_CARGO, 197m, 11.325kn
Frequency (Hz) [2012-09-28 09:30:21]
3154, , CT_CARGO, 225m, 14.2857kn
Frequency (Hz) [2013-04-01 16:15:21]
dB re 1 μPa²/Hz @ 1m

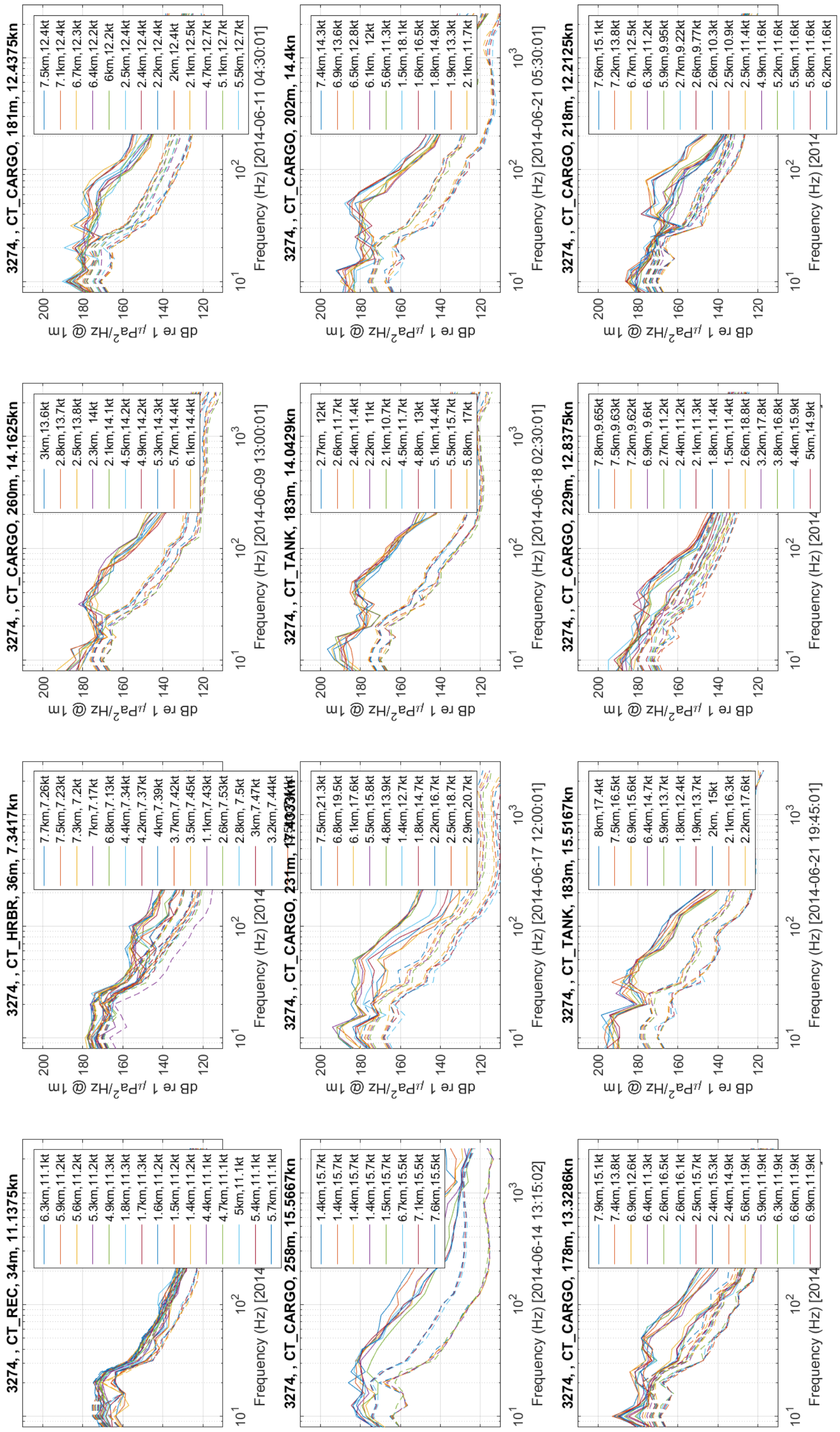

3274, , CT_CARGO, 171m, NaNkn
Frequency (Hz) [2014-01-01 07:45:02]
3274, , CT_REC, 13.46m, 4.9105kn
3274, , CT_PASSENGER, 186m, 14.425kn
Frequency (Hz) [2014-01-18 04:48:01]
3274, , CT_TANK, 185m, 10.7778kn
3274, , CT_CARGO, 260m, 16.4167kn
Frequency (Hz) [2014-01-22 01:45:01]
3274, , CT_TANK, 243m, 12.0857kn
Frequency (Hz) [2014-01-28 13:30:01]
3274, , CT_CARGO, 199m, 16.3167kn
Frequency (Hz) [2014-01-30 08:45:02]
3274, , CT_CARGO, 225m, 11.95kn
Frequency (Hz) [2014-02-04 21:30:01]
3274, , CT_TANK, 243m, 14.8714kn
Frequency (Hz) [2014-02-07 03:45:01]
3274, , CT_CARGO, 100m, 12.35kn
3274, , CT_CARGO, 260m, 15.3167kn
Frequency (Hz) [2014-02-19 00:15:01]
3274, , CT_CARGO, 188m, 15.1kn
Frequency (Hz) [2014-02-21 07:00:02]
dB re 1 μPa²/Hz @ 1m

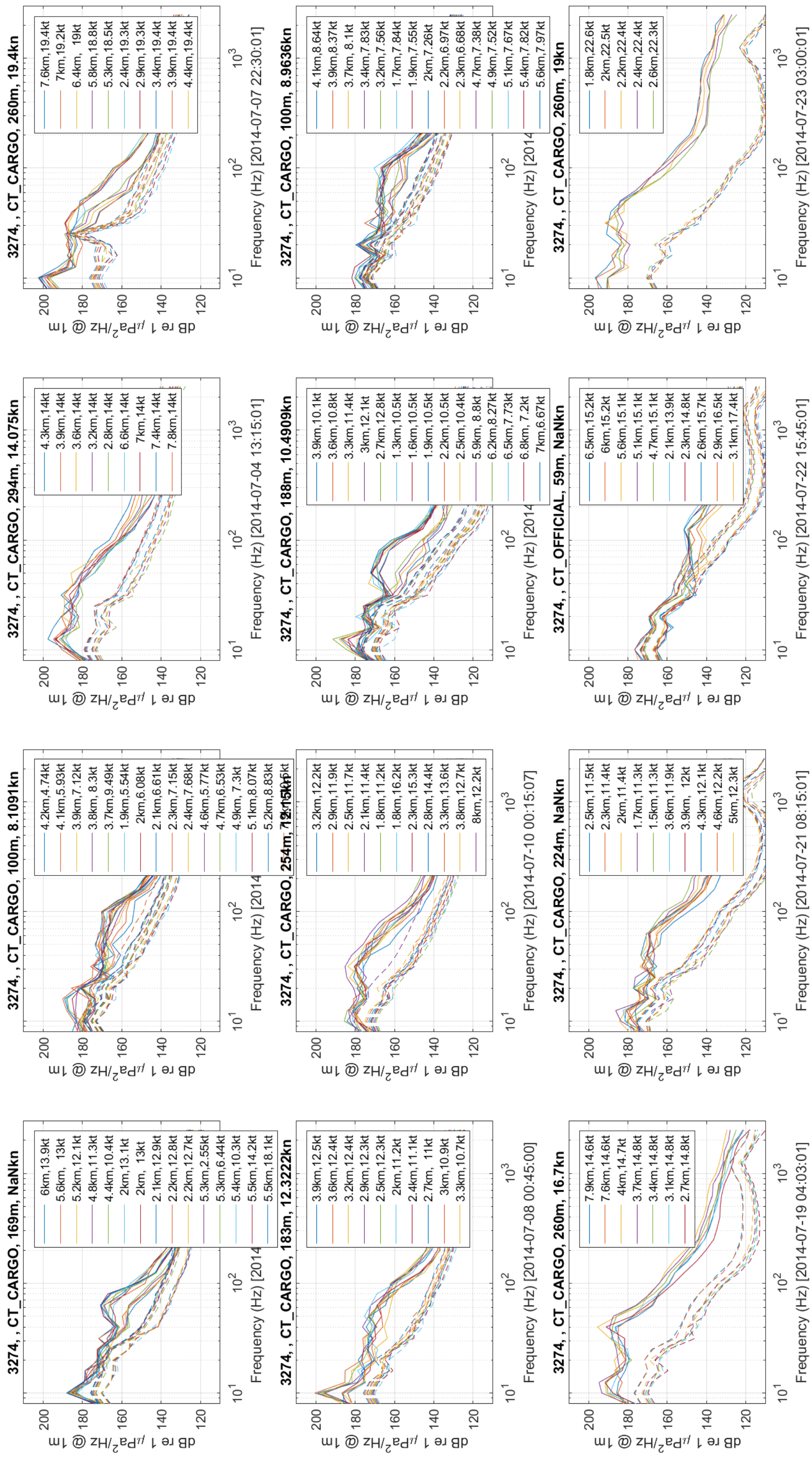

3274, , CT_CARGO, 231m, 16.2kn
Frequency (Hz) [2014-02-25 15:45:01]
3274, , CT_CARGO, 179m, 13.4125kn
Frequency (Hz) [2014-02-23 04:30:01]
3274, , CT_CARGO, 186m, 10.46kn
Frequency (Hz) [2014-02-22 13:45:01]
3274, , CT_CARGO, 100m, 12.7kn
Frequency (Hz) [2014-02-22 00:00:01]
3274, , CT_CARGO, 190m, 13.1875kn
3274, , CT_TANK, 243m, 11.6kn
Frequency (Hz) [2014-03-02 11:00:02]
3274, , CT_CARGO, 100m, 12.7375kn
3274, , CT_CARGO, 260m, 15.7kn
Frequency (Hz) [2014-02-26 19:15:01]
3274, , CT_CARGO, 169m, 13.125kn
Frequency (Hz) [2014-03-10 02:15:01]
3274, , CT_TANK, 243m, 9.62kn
3274, , CT_TANK, 122m, 12.1375kn
3274, , CT_CARGO, 100m, 12.4375kn

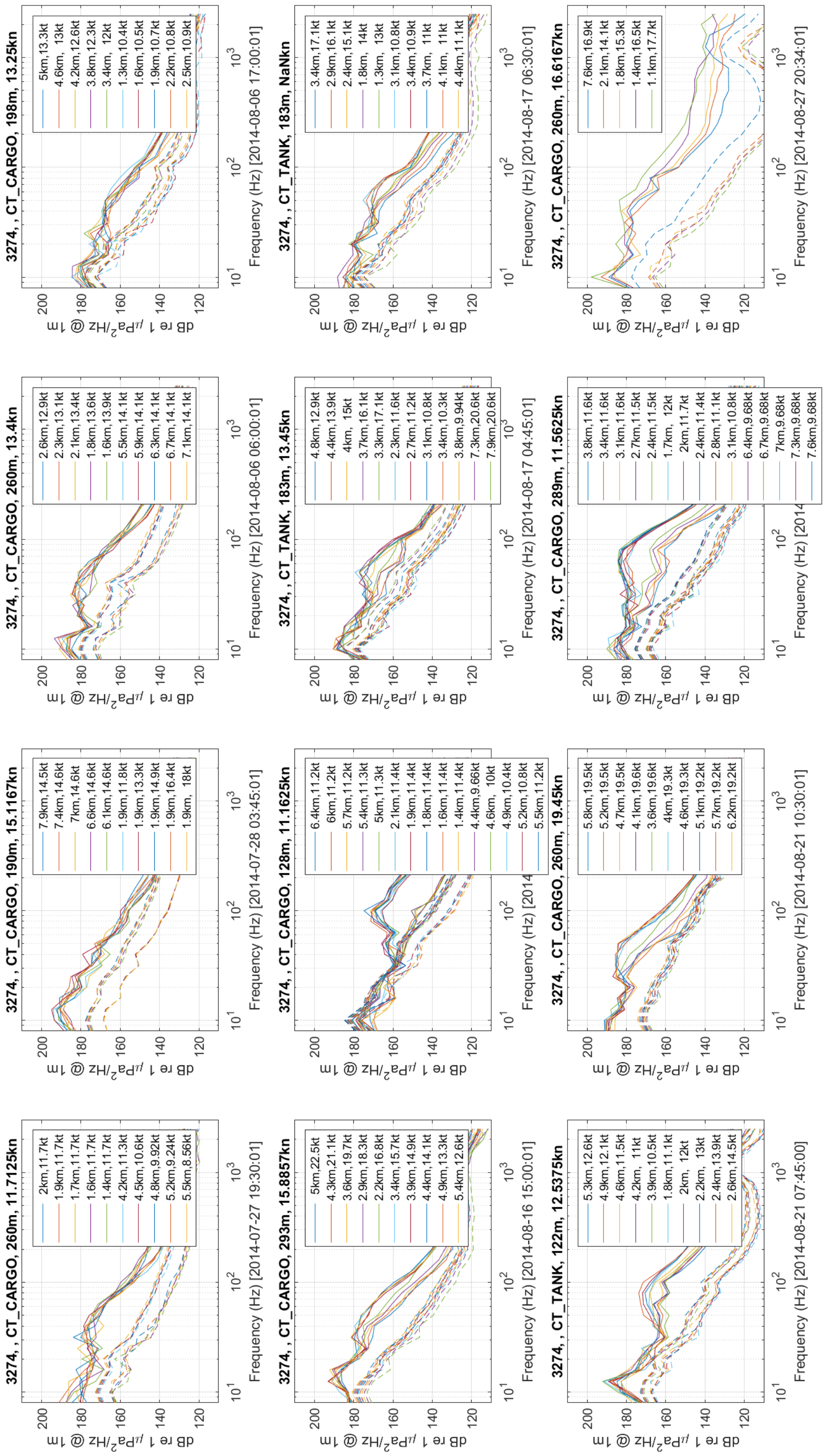

3274, , CT_CARGO, 158m, 12.025kn
4.8km,12.7kt
4.5km,12.6kt
4.1km,12.4kt
3.7km,12.3kt
3.4km,12.2kt
1.8km,12.2kt
2.1km,12.2kt
2.4km,12.2kt
2.7km,12.1kt
3km,12.1kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-03-11 04:15:02]
3274, , CT_CARGO, 294m, 14.8167kn
2.5km,15.3kt
2.5km,15.4kt
2.5km,15.4kt
2.5km,15.4kt
2.5km,15.4kt
6.4km,15.3kt
6.9km,15.3kt
7.3km,15.3kt
7.8km,15.3kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-03-14 12:30:01]
3274, , CT_CARGO, 181m, 11.85kn
6.6km,11.9kt
6.2km,11.9kt
5.8km,11.9kt
5.5km,11.9kt
5.1km,11.9kt
1.2km,11.8kt
1.1km,11.8kt
4.4km,11.8kt
4.7km,11.8kt
5.1km,11.8kt
5.5km,11.8kt
5.8km,11.8kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-03-17 05:00:01]
3274, , CT_CARGO, 260m, 11.45kn
4.8km,11.4kt
4.5km,11.5kt
4.2km,11.5kt
3.9km,11.5kt
3.6km,11.6kt
2.5km,11.7kt
2.6km,11.8kt
2.7km,11.8kt
2.8km,11.8kt
2.9km,11.9kt
6.4km,11.5kt
6.7km,11.5kt
7.1km,11.5kt
7.4km,11.5kt
7.8km,11.5kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
3274, , CT_CARGO, 100m, 10.9444kn
4.8km,10.9kt
4.5km,10.9kt
4.3km,10.9kt
4km,10.9kt
3.7km, 11kt
2.2km,11.1kt
2.4km,11.1kt
2.5km,11.2kt
2.7km,11.2kt
2.9km,11.3kt
6.2km,10.9kt
6.5km,10.9kt
6.8km, 11kt
7.1km, 11kt
7.5km,11.1kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
3274, , CT_CARGO, 100m, 11.8125kn
7.2km,11.9kt
6.8km,11.8kt
6.5km,11.8kt
6.1km,11.8kt
5.8km,11.8kt
2.4km, 12kt
2.3km, 12kt
2.3km, 12kt
2.2km, 12kt
2.1km,11.9kt
4.5km, 12kt
4.9km, 12kt
5.2km, 12kt
5.6km, 12kt
5.9km, 12kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
3274, , CT_TANK, 114m, NaNkn
7.1km,12.4kt
6.7km,12.4kt
6.3km,12.5kt
6km,12.5kt
5.6km,12.6kt
2.3km,14.8kt
2.2km, 14kt
2km,13.3kt
2km,12.7kt
2.2km,12.7kt
5.3km,12.8kt
5.7km,12.8kt
6km,12.8kt
6.4km,12.8kt
6.8km,12.8kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
3274, , CT_TANK, 183m, 12.55kn
1.7km,12.3kt
1.4km,12.2kt
1.1km,12.2kt
4.1km, 13kt
4.5km, 13kt
4.9km,13.1kt
5.3km,13.2kt
5.7km,13.2kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-03-26 04:00:00]
3274, , CT_CARGO, 294m, 15.3333kn
1.6km,15.3kt
1.9km,15.3kt
2.1km,15.3kt
2.4km,15.3kt
2.7km,15.3kt
7.4km,15.4kt
7.9km,15.4kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-04-05 11:15:01]
3274, , CT_CARGO, 175m, 11.75kn
6.7km, 12kt
6.3km, 12kt
6km, 12kt
5.6km, 12kt
5.3km, 12kt
2.3km,11.8kt
2.3km,11.8kt
2.2km,11.8kt
2.2km,11.8kt
2.1km,11.8kt
4.9km,11.6kt
5.2km,11.6kt
5.6km,11.7kt
5.9km,11.8kt
6.3km,11.9kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
3274, , CT_CARGO, 260m, 16.0286kn
5.6km,15.9kt
5.2km, 16kt
4.7km,16.1kt
4.3km,16.2kt
3.8km,16.4kt
2.8km,16.1kt
3.3km,16.1kt
3.7km,16.1kt
4.2km,16.1kt
4.6km,16.1kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-04-14 12:30:01]
3274, , CT_CARGO, 231m, 16.75kn
2.8km,16.7kt
2.4km,16.7kt
2.1km,16.7kt
1.7km,16.7kt
1.4km,16.8kt
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-04-15 03:15:01]

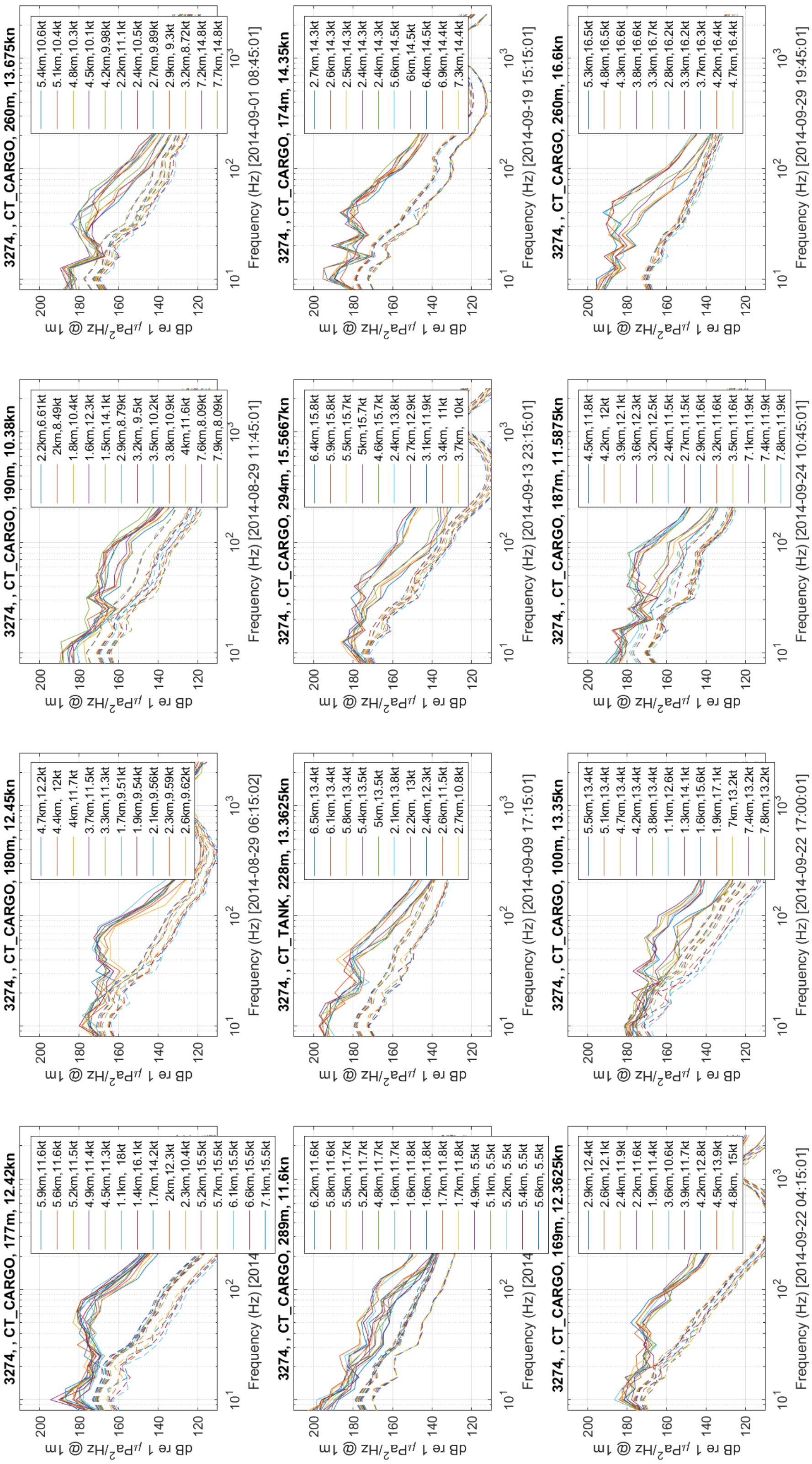

3274, , CT_CARGO, 199m, 11.3375kn
Frequency (Hz) [2014-04-27 14:15:00]
3274, , CT_CARGO, 138m, 11.8375kn
3274, , CT_CARGO, 260m, 18.95kn
Frequency (Hz) [2014-04-23 10:30:01]
3274, , CT_CARGO, 100m, 11.725kn
Frequency (Hz) [2014-04-22 02:00:01]
3274, , CT_CARGO, 169m, 11.325kn
Frequency (Hz) [2014-05-04 05:30:01]
3274, , CT_CARGO, 188m, 11.75kn
Frequency (Hz) [2014-05-04 04:45:00]
3274, , CT_CARGO, 180m, 8.8333kn
3274, , CT_CARGO, 100m, 14.1143kn
Frequency (Hz) [2014-04-28 21:30:01]
3274, , CT_CARGO, 169m, 12.9375kn
Frequency (Hz) [2014-05-13 19:48:02]
3274, , CT_CARGO, 260m, 13.6714kn
Frequency (Hz) [2014-05-12 16:45:01]
Frequency (Hz) [2014-05-06 11:15:01]
3274, , CT_CARGO, 249m, 15.75kn
Frequency (Hz) [2014-05-06 02:45:02]
dB re 1 μPa²/Hz @ 1m

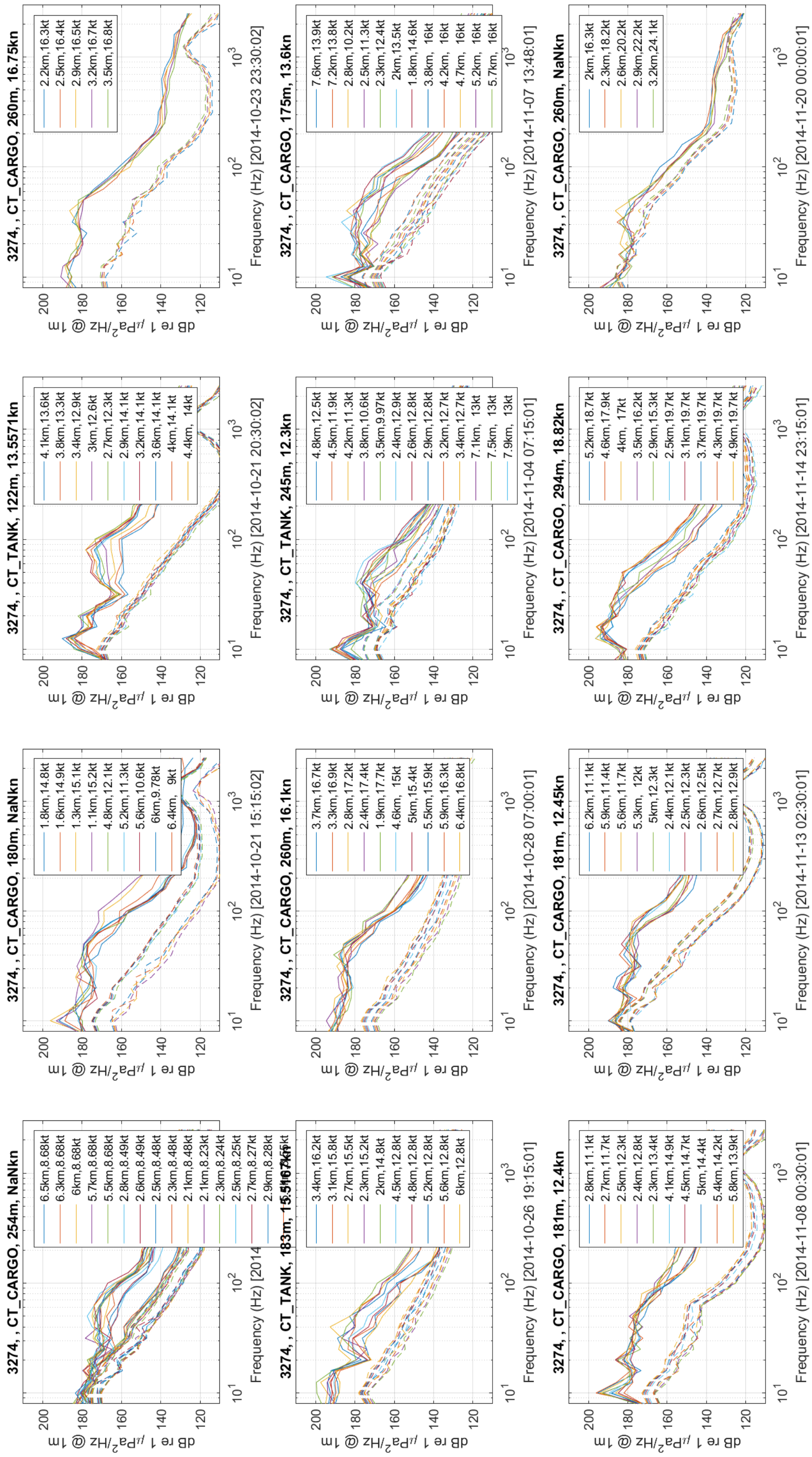

3274, , CT_CARGO, 260m, 17.4667kn
3274, , CT_CARGO, 100m, 11.8125kn
3274, , CT_CARGO, 100m, 14.225kn
3274, , CT_CARGO, 180m, 11.1kn
3274, , CT_CARGO, 180m, 12.5kn
3274, , CT_CARGO, 260m, 14.4571kn
3274, , CT_TANK, 134m, 10.475kn
3274, , CT_TANK, 183m,
3274, , CT_CARGO, 202m, 14.675kn
3274, , CT_CARGO, 100m, 10.1444kn
3274, , CT_TANK, 131m, 12.9714kn
3274, , CT_CARGO, 260m, 14.2429kn
Frequency (Hz)
dB re 1 μPa²/Hz @ 1m

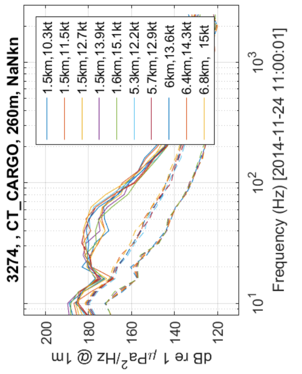

3274, , CT_CARGO, 181m, 12.4375kn
Frequency (Hz) [2014-06-11 04:30:01]
3274, , CT_CARGO, 260m, 14.1625kn
Frequency (Hz) [2014-06-09 13:00:01]
3274, , CT_HRBR, 36m, 7.3417kn
3274, , CT_REC, 34m, 11.1375kn
3274, , CT_CARGO, 202m, 14.4kn
Frequency (Hz) [2014-06-21 05:30:01]
3274, , CT_TANK, 183m, 14.0429kn
Frequency (Hz) [2014-06-18 02:30:01]
3274, , CT_CARGO, 231m, 17.4033kn
Frequency (Hz) [2014-06-17 12:00:01]
3274, , CT_CARGO, 258m, 15.5667kn
Frequency (Hz) [2014-06-14 13:15:02]
3274, , CT_CARGO, 218m, 12.2125kn
3274, , CT_CARGO, 229m, 12.8375kn
3274, , CT_TANK, 183m, 15.5167kn
Frequency (Hz) [2014-06-21 19:45:01]
3274, , CT_CARGO, 178m, 13.3286kn
dB re 1 μPa²/Hz @ 1m

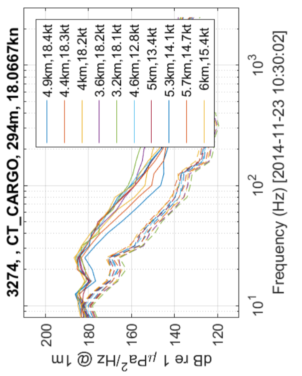

3274, , CT_CARGO, 260m, 19.4kn
Frequency (Hz) [2014-07-07 22:30:01]
3274, , CT_CARGO, 100m, 8.9636kn
3274, , CT_CARGO, 260m, 19kn
Frequency (Hz) [2014-07-23 03:00:01]
3274, , CT_CARGO, 294m, 14.075kn
Frequency (Hz) [2014-07-04 13:15:01]
3274, , CT_CARGO, 188m, 10.4909kn
3274, , CT_OFFICIAL, 59m, NaNkn
Frequency (Hz) [2014-07-22 15:45:01]
3274, , CT_CARGO, 100m, 8.1091kn
Frequency (Hz) [2014-07-10 00:15:07]
3274, , CT_CARGO, 224m, NaNkn
Frequency (Hz) [2014-07-21 08:15:01]
3274, , CT_CARGO, 169m, NaNkn
3274, , CT_CARGO, 183m, 12.3222kn
Frequency (Hz) [2014-07-08 00:45:00]
3274, , CT_CARGO, 260m, 16.7kn
Frequency (Hz) [2014-07-19 04:03:01]
dB re 1 μPa²/Hz @ 1m

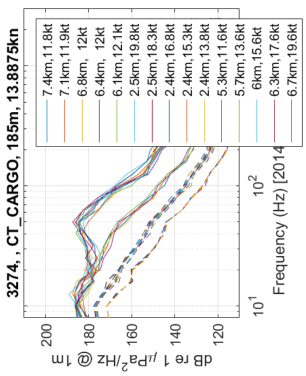

3274, , CT_CARGO, 198m, 13.25kn
3274, , CT_TANK, 183m, NaNkn
3274, , CT_CARGO, 260m, 16.6167kn
3274, , CT_CARGO, 260m, 13.4kn
3274, , CT_TANK, 183m, 13.45kn
3274, , CT_CARGO, 289m, 11.5625kn
3274, , CT_CARGO, 190m, 15.1167kn
3274, , CT_CARGO, 128m, 11.1625kn
3274, , CT_CARGO, 260m, 19.45kn
3274, , CT_CARGO, 260m, 11.7125kn
3274, , CT_CARGO, 293m, 15.8857kn
3274, , CT_TANK, 122m, 12.5375kn

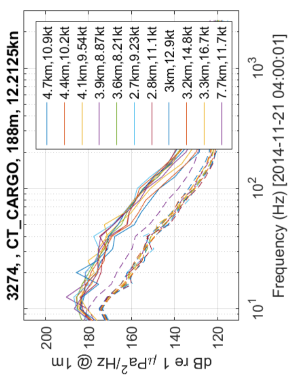

3274, , CT_CARGO, 260m, 13.675kn
Frequency (Hz) [2014-09-01 08:45:01]
3274, , CT_CARGO, 174m, 14.35kn
Frequency (Hz) [2014-09-19 15:15:01]
3274, , CT_CARGO, 260m, 16.6kn
Frequency (Hz) [2014-09-29 19:45:01]
3274, , CT_CARGO, 190m, 10.38kn
Frequency (Hz) [2014-08-29 11:45:01]
3274, , CT_CARGO, 294m, 15.5667kn
Frequency (Hz) [2014-09-13 23:15:01]
3274, , CT_CARGO, 187m, 11.5875kn
Frequency (Hz) [2014-09-24 10:45:01]
3274, , CT_CARGO, 180m, 12.45kn
Frequency (Hz) [2014-08-29 06:15:02]
3274, , CT_TANK, 228m, 13.3625kn
Frequency (Hz) [2014-09-09 17:15:01]
3274, , CT_CARGO, 100m, 13.35kn
Frequency (Hz) [2014-09-22 17:00:01]
3274, , CT_CARGO, 177m, 12.42kn
3274, , CT_CARGO, 289m, 11.6kn
3274, , CT_CARGO, 169m, 12.3625kn
Frequency (Hz) [2014-09-22 04:15:01]
dB re 1 μPa²/Hz @ 1m

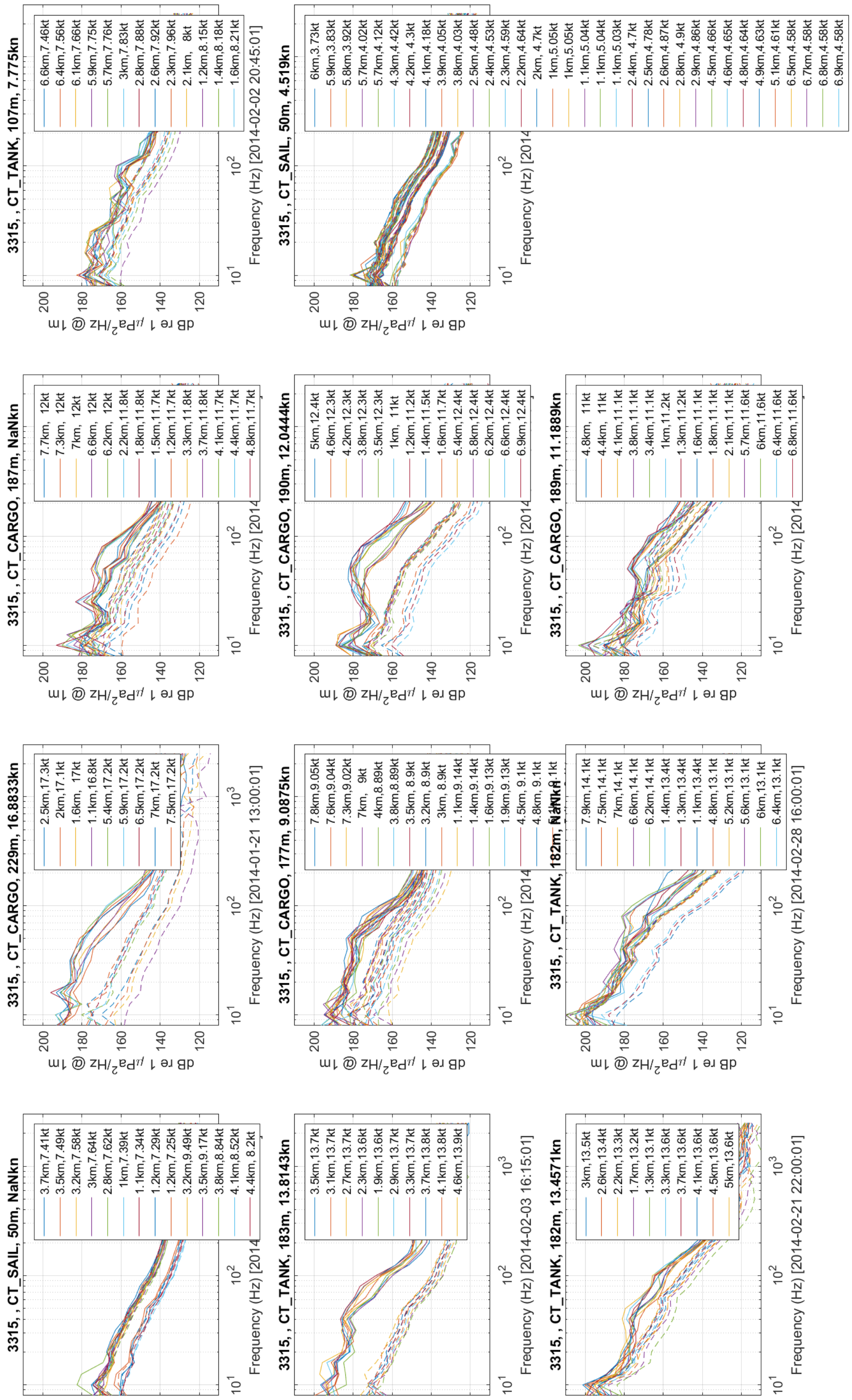

3274, , CT_CARGO, 260m, 16.75kn
Frequency (Hz) [2014-10-23 23:30:02]
3274, , CT_TANK, 122m, 13.5571kn
Frequency (Hz) [2014-10-21 20:30:02]
3274, , CT_CARGO, 180m, NaNkn
Frequency (Hz) [2014-10-21 15:15:02]
3274, , CT_CARGO, 254m, NaNkn
3274, , CT_CARGO, 175m, 13.6kn
Frequency (Hz) [2014-11-07 13:48:01]
3274, , CT_TANK, 245m, 12.3kn
Frequency (Hz) [2014-11-04 07:15:01]
3274, , CT_CARGO, 260m, 16.1kn
Frequency (Hz) [2014-10-28 07:00:01]
3274, , CT_TANK, 183m, 15.5167kn
Frequency (Hz) [2014-10-26 19:15:01]
3274, , CT_CARGO, 260m, NaNkn
Frequency (Hz) [2014-11-20 00:00:01]
3274, , CT_CARGO, 294m, 18.82kn
Frequency (Hz) [2014-11-14 23:15:01]
3274, , CT_CARGO, 181m, 12.45kn
Frequency (Hz) [2014-11-13 02:30:01]
3274, , CT_CARGO, 181m, 12.4kn
Frequency (Hz) [2014-11-08 00:30:01]
dB re 1 μPa²/Hz @ 1m

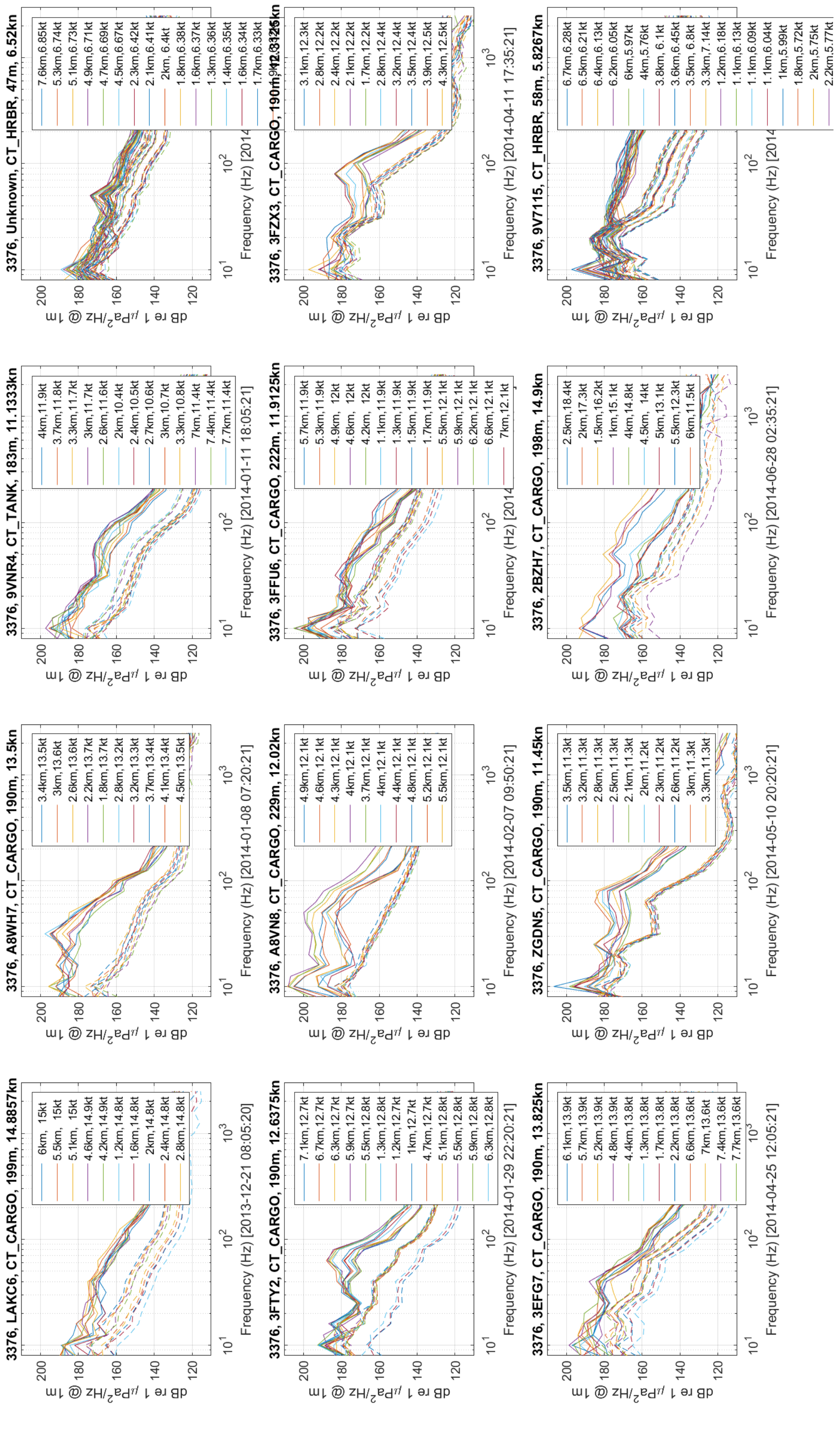

3274, , CT_CARGO, 260m, NaNkn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-24 11:00:01]
1.5km,10.3kt
1.5km,11.5kt
1.5km,12.7kt
1.5km,13.9kt
1.6km,15.1kt
5.3km,12.2kt
5.7km,12.9kt
6km,13.6kt
6.4km,14.3kt
6.8km, 15kt

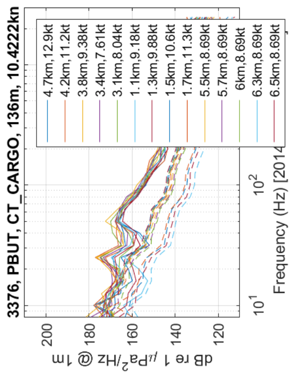

3274, , CT_CARGO, 294m, 18.0667kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-23 10:30:02]
4.9km,18.4kt
4.4km,18.3kt
4km,18.2kt
3.6km,18.2kt
3.2km,18.1kt
4.6km,12.8kt
5km,13.4kt
5.3km,14.1kt
5.7km,14.7kt
6km,15.4kt

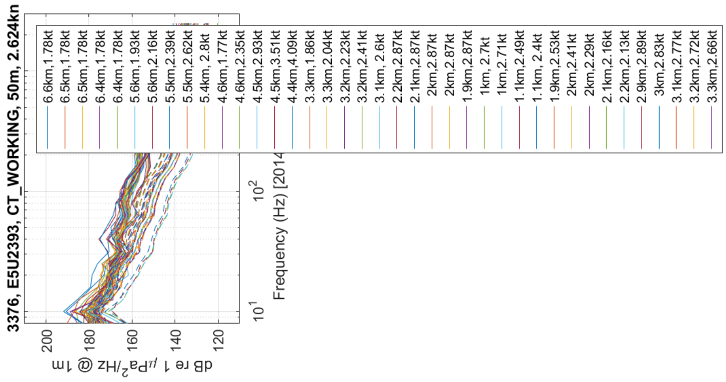

3274, , CT_CARGO, 185m, 13.8875kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
7.4km,11.8kt
7.1km,11.9kt
6.8km, 12kt
6.4km, 12kt
6.1km,12.1kt
2.5km,19.8kt
2.5km,18.3kt
2.4km,16.8kt
2.4km,15.3kt
2.4km,13.8kt
5.3km,11.6kt
5.7km,13.6kt
6km,15.6kt
6.3km,17.6kt
6.7km,19.6kt

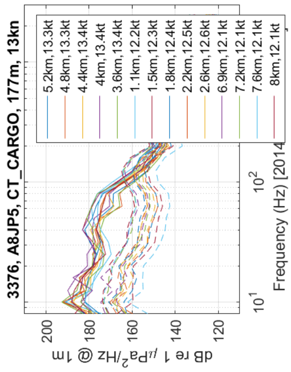

3274, , CT_CARGO, 188m, 12.2125kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-11-21 04:00:01]
4.7km,10.9kt
4.4km,10.2kt
4.1km,9.54kt
3.9km,8.87kt
3.6km,8.21kt
2.7km,9.23kt
2.8km,11.1kt
3km,12.9kt
3.2km,14.8kt
3.3km,16.7kt
7.7km,11.7kt

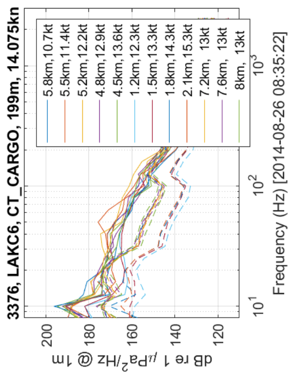

3315, , CT_TANK, 107m, 7.775kn
3315, , CT_SAIL, 50m, 4.519kn
3315, , CT_CARGO, 187m, NaNkn
3315, , CT_CARGO, 190m, 12.0444kn
3315, , CT_CARGO, 189m, 11.1889kn
3315, , CT_CARGO, 229m, 16.8833kn
3315, , CT_CARGO, 177m, 9.0875kn
3315, , CT_SAIL, 50m, NaNkn
3315, , CT_TANK, 183m, 13.8143kn
3315, , CT_TANK, 182m, 13.4571kn

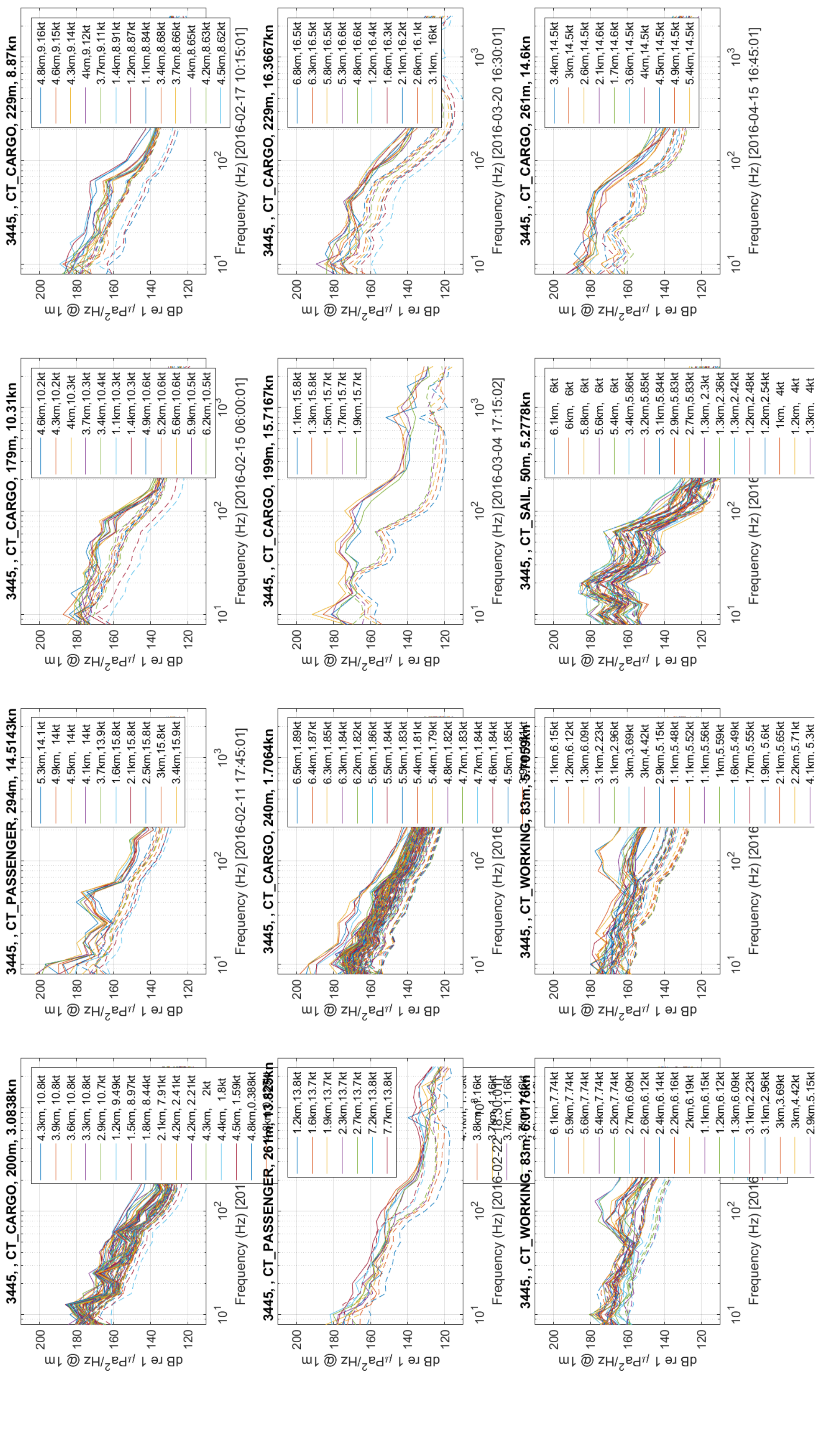

3376, Unknown, CT_HRBR, 47m, 6.52kn
3376, 9VNR4, CT_TANK, 183m, 11.1333kn
3376, A8WH7, CT_CARGO, 190m, 13.5kn
3376, LAKC6, CT_CARGO, 199m, 14.8857kn
3376, 3FZX3, CT_CARGO, 190m, 12.3125kn
3376, 3FFU6, CT_CARGO, 222m, 11.9125kn
3376, A8VN8, CT_CARGO, 229m, 12.02kn
3376, 3FTY2, CT_CARGO, 190m, 12.6375kn
3376, 9V7115, CT_HRBR, 58m, 5.8267kn
3376, 2BZH7, CT_CARGO, 198m, 14.9kn
3376, ZGDN5, CT_CARGO, 190m, 11.45kn
3376, 3EFG7, CT_CARGO, 190m, 13.825kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-04-11 17:35:21]
Frequency (Hz) [2014-01-11 18:05:21]
Frequency (Hz) [2014-01-08 07:20:21]
Frequency (Hz) [2013-12-21 08:05:20]
Frequency (Hz) [2014-02-07 09:50:21]
Frequency (Hz) [2014-01-29 22:20:21]
Frequency (Hz) [2014-06-28 02:35:21]
Frequency (Hz) [2014-05-10 20:20:21]
Frequency (Hz) [2014-04-25 12:05:21]

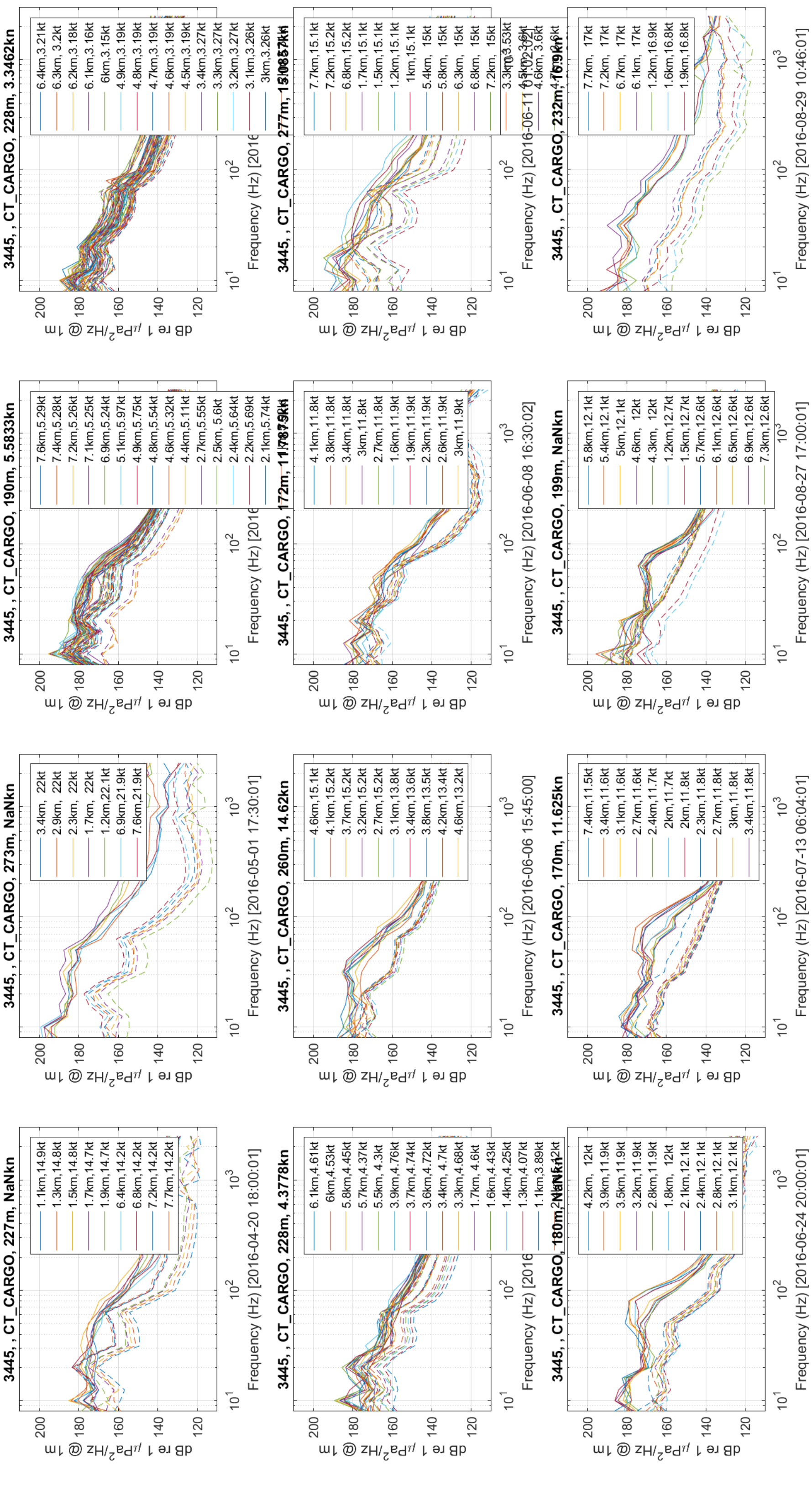

3376, PBUT, CT_CARGO, 136m, 10.4222kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
4.7km,12.9kt
4.2km,11.2kt
3.8km,9.38kt
3.4km,7.61kt
3.1km,8.04kt
1.1km,9.18kt
1.3km,9.88kt
1.5km,10.6kt
1.7km,11.3kt
5.5km,8.69kt
5.7km,8.69kt
6km,8.69kt
6.3km,8.69kt
6.5km,8.69kt

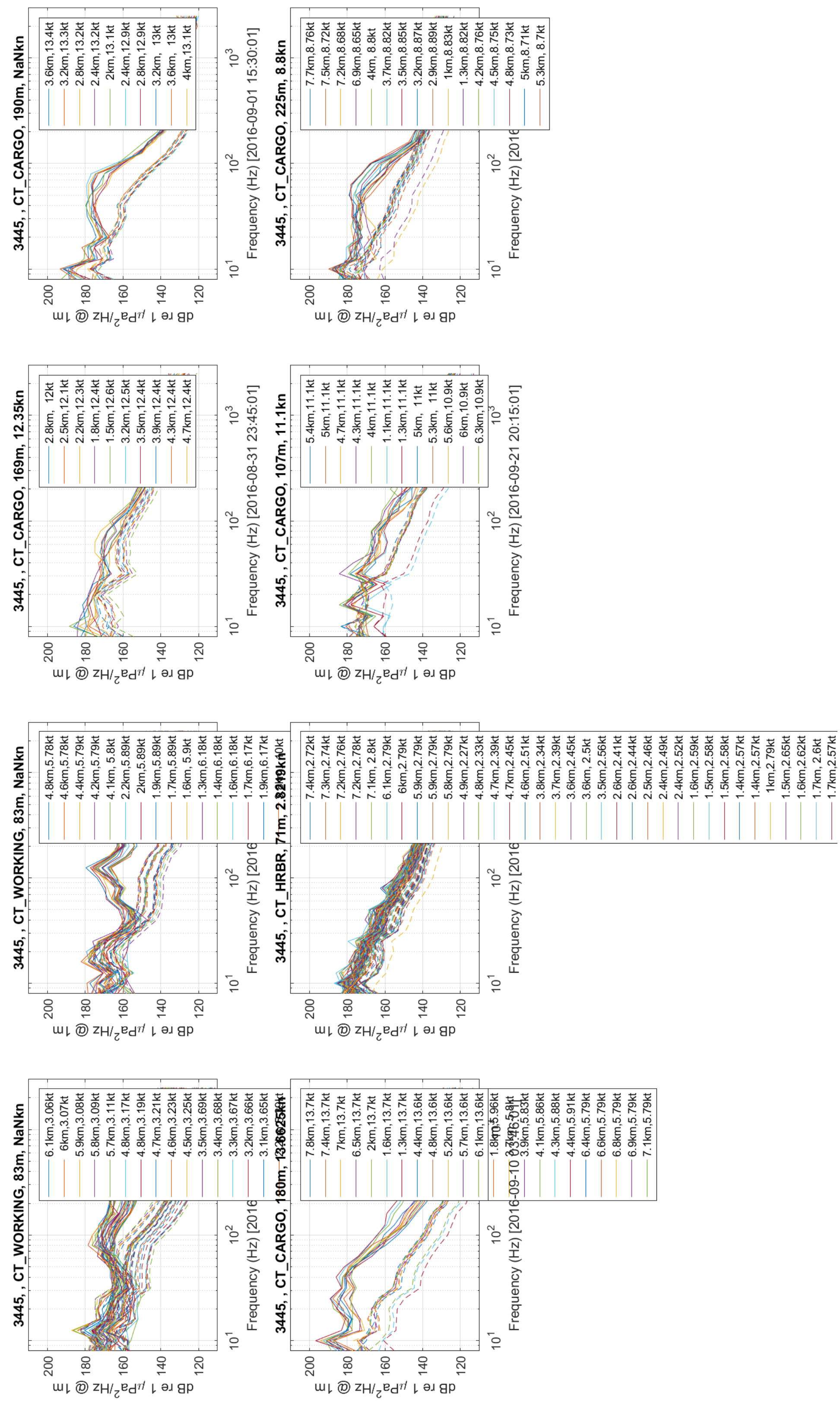

3376, E5U2393, CT_WORKING, 50m, 2.624kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
6.6km,1.78kt
6.5km,1.78kt
6.5km,1.78kt
6.4km,1.78kt
6.4km,1.78kt
5.6km,1.93kt
5.6km,2.16kt
5.5km,2.39kt
5.5km,2.62kt
5.4km, 2.8kt
4.6km,1.77kt
4.6km,2.35kt
4.5km,2.93kt
4.5km,3.51kt
4.4km,4.09kt
3.3km,1.86kt
3.3km,2.04kt
3.2km,2.23kt
3.2km,2.41kt
3.1km, 2.6kt
2.2km,2.87kt
2.1km,2.87kt
2km,2.87kt
2km,2.87kt
1.9km,2.87kt
1km, 2.7kt
1km,2.71kt
1.1km,2.49kt
1.1km, 2.4kt
1.9km,2.53kt
2km,2.41kt
2km,2.29kt
2.1km,2.16kt
2.2km,2.13kt
2.9km,2.89kt
3km,2.83kt
3.1km,2.77kt
3.2km,2.72kt
3.3km,2.66kt


3376, A8JP5, CT_CARGO, 177m, 13kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014
5.2km,13.3kt
4.8km,13.3kt
4.4km,13.4kt
4km,13.4kt
3.6km,13.4kt
1.1km,12.2kt
1.5km,12.3kt
1.8km,12.4kt
2.2km,12.5kt
2.6km,12.6kt
6.9km,12.1kt
7.2km,12.1kt
7.6km,12.1kt
8km,12.1kt


3376, LAKC6, CT_CARGO, 199m, 14.075kn
dB re 1 μPa²/Hz @ 1m
Frequency (Hz) [2014-08-26 08:35:22]
5.8km,10.7kt
5.5km,11.4kt
5.2km,12.2kt
4.8km,12.9kt
4.5km,13.6kt
1.2km,12.3kt
1.5km,13.3kt
1.8km,14.3kt
2.1km,15.3kt
7.2km, 13kt
7.6km, 13kt
8km, 13kt


3445, , CT_CARGO, 229m, 8.87kn
Frequency (Hz) [2016-02-17 10:15:01]
3445, , CT_CARGO, 179m, 10.31kn
Frequency (Hz) [2016-02-15 06:00:01]
3445, , CT_PASSENGER, 294m, 14.5143kn
Frequency (Hz) [2016-02-11 17:45:01]
3445, , CT_CARGO, 200m, 3.0838kn
3445, , CT_CARGO, 229m, 16.3667kn
Frequency (Hz) [2016-03-20 16:30:01]
3445, , CT_CARGO, 199m, 15.7167kn
Frequency (Hz) [2016-03-04 17:15:02]
3445, , CT_CARGO, 240m, 1.7064kn
3445, , CT_CARGO, 261m, 14.6kn
Frequency (Hz) [2016-04-15 16:45:01]
3445, , CT_SAIL, 50m, 5.2778kn
dB re 1 μPa²/Hz @ 1m


3445, , CT_CARGO, 228m, 3.3462kn
3445, , CT_CARGO, 190m, 5.5833kn
3445, , CT_CARGO, 273m, NaNkn
Frequency (Hz) [2016-05-01 17:30:01]
3445, , CT_CARGO, 227m, NaNkn
Frequency (Hz) [2016-04-20 18:00:01]
Frequency (Hz) [2016-06-08 16:30:02]
3445, , CT_CARGO, 260m, 14.62kn
Frequency (Hz) [2016-06-06 15:45:00]
3445, , CT_CARGO, 228m, 4.3778kn
Frequency (Hz) [2016-08-29 10:46:01]
3445, , CT_CARGO, 199m, NaNkn
Frequency (Hz) [2016-08-27 17:00:01]
3445, , CT_CARGO, 170m, 11.625kn
Frequency (Hz) [2016-07-13 06:04:01]
Frequency (Hz) [2016-06-24 20:00:01]
dB re 1 μPa²/Hz @ 1m


3445, , CT_CARGO, 190m, NaNkn
Frequency (Hz) [2016-09-01 15:30:01]
3445, , CT_CARGO, 225m, 8.8kn
3445, , CT_CARGO, 169m, 12.35kn
Frequency (Hz) [2016-08-31 23:45:01]
3445, , CT_CARGO, 107m, 11.1kn
Frequency (Hz) [2016-09-21 20:15:01]
3445, , CT_WORKING, 83m, NaNkn
3445, , CT_HRBR, 71m, 2.82kn
3445, , CT_WORKING, 83m, NaNkn
3445, , CT_CARGO, 180m, 13.66kn
dB re 1 µPa²/Hz @ 1m

# APPENDIX C – AIS DATA FILE FORMATS

Passes files

Each row of the Passes files give a period a vessel qualified (eg within 1km of the logger & no other vessel within 5km)

The columns of the Passes file are:
**PASSID** = An identifier given to each vessel/pass that went within 1km when no other vessel was within 5km of the logger
**CRAFT_ID** = A vessel identifier (AIS data up to 10/2016 this is from AMSA, after 10/2016 this is just the vessel MMSI)
**L0** = Position ID in the original AIS data of the segment when the vessel enters 1km zone (or other vessels leave 5km)
**L1**= Position ID in the original AIS data of the segment when the vessel leaves 1km zone (or another vessel comes into 5km)
**T0** = Start Time (UTC) of when vessel is within 1km of logger and no other vessel is within 5km
**T1**= End Time (UTC) of when vessel is within 1km of logger and no other vessel is within 5km (e.g vessel leaves or another vessel comes into 5km zone)
**MMSI** = Vessel identifier from AIS data
**CRAFT_TYPE** = The AIS info on the vessel type
**CRAFT_CLASS** = CSIRO classification of type into more simple classes
**LENGTH** = The length of the vessel (metres)
**DURATION** = The time in mins the vessel/pass qualified (e.g. within 1km & no other vessel within 5km)

15km files
Each row of the 15km file are a AIS line segment. If you take all the rows with a specific PASSID it will give you the AIS segments

For the vessel 7km before, during and 7km after the pass referred to with that PASSID in the passes file.

The columns of the 15km file are mainly AIS info plus some derived columns:
**PASSID** = The pass identifier same as the passes file
**POSITION_ID** = The identifier for each AIS row in the full data set,
**CRAFT_ID**= A vessel identifier (AIS data up to 10/2016 this is from AMSA, after 10/2016 this is just the vessel MMSI)
**MMSI =** Vessel identifier from AIS data
**IMO** = Vessel hull number (only larger vessels)
**NAME** = Vessel name transmitted in AIS data
**LON0** = Start Longitude of line segment
**LAT0**= Start Latitude of line segment
**TIME0** = Start Time (UTC) of line segment
**LON1** = End Longitude of line segment
**LAT1** = End Latitude of line segment
**TIME1** = End Time (UTC) of line segment
**COURSE_DEGREES** = The heading/course (Deg) transmitted in AIS data
**SPEED_KNOTS** = The speed (Knots) transmitted in AIS
**CRAFT_TYPE** = The AIS info on the vessel type

**LENGTH_METRES** = The vessel length (metres)
**BEAM_METRES** = Beam of the vessel (metres)
**CLS** = AIS class (A= larger commercial required AIS, B= smaller vessels voluntary AIS)
**CRAFT_CLASS** = My classification of type into more simple classes
**NATION** = Flag country of the vessel based on MMSI number
**DESTINATION** = The AIS transmitted destination of the voyage
**LEN_TIME** = Length of time (seconds) the vessel took to cover segment
**LEN_DIST** = Distance/length of segment (km)
**SPEED_CALC** = The calculated average speed for the line segment (Knots)

# APPENDIX D – AIS VESSEL TYPES INCLUDED IN EACH VESSEL CLASS

AIS data file formats
Vessel class: CT_CARGO
  Cargo ship - All
  Cargo ship - No additional info
  Cargo ship - Carrying DG, HS, or MP, IMO Hazard or pollutant category C
  Livestock carrier
  Cargo ship - Carrying DG, HS, or MP, IMO Hazard or pollutant category A
  Cargo ship - Carrying DG, HS, or MP, IMO Hazard or pollutant category B
  Vehicle carrier
  Other - All

Vessel class: CT_WORKING
  Anchor Handling Vessel
  Offshore Supply Ship
  Towing Long/Large
  Salvage/rescue ship

Vessel class: CT_SAIL
  Sailing

Vessel class: CT_REC
  CT_REC

Vessel class: CT_HRBR
  Other - No additional info
  Towing Long/Large
  Tug

Vessel class: CT_TANK
  Tanker - All
  Tanker - Carrying DG, HS, or MP, IMO Hazard or pollutant category B
  Tanker - No additional info

Vessel class: CT_UNKNOWN
  Unknown

Vessel class: CT_PASSENGER
  Cruise Ship

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