Australian Government

Department of Defence

Defence Science and
Technology Organisation

Environmental Mitigation Ranges Around Australia

Paul Clarke

DSTO-GD-0395

Australian Government
Department of Defence
Defence Science and
Technology Organisation

Environmental Mitigation Ranges Around Australia

Paul Clarke

Maritime Operations Division
Systems Sciences Laboratory

DSTO-GD-0395

ABSTRACT

URS Australia is currently writing a document "Environmental Management Plan for Australian Maritime Exercise Areas" for the ADF. To help URS, MOD has modelled the expected sound pressure levels for a number of different environments and sonar frequencies around Australia. This was used to calculate the mitigation range that could be used when operating different sonars in Australian waters.

RELEASE LIMITATION

Approved for public release

Published by

DSTO Systems Sciences Laboratory
PO Box 1500
Edinburgh South Australia 5111 Australia

Telephone: (08) 8259 5555
Fax: (08) 8259 6567

AR-013-045
February 2004

APPROVED FOR PUBLIC RELEASE

Environmental Mitigation Ranges Around Australia

Executive Summary

URS Australia is currently writing a document "Environmental Management Plan for Australian Maritime Exercise Areas" for the ADF. To help URS, MOD has modelled the expected received sound pressure levels for a number of different environments and sonar frequencies around Australia. The maximum ranges the sound pressure levels dropped below 182 and 160 dB were then calculated for a number of different sonars operating at levels indicative of or over-estimating full power. Since these ranges varied depending on the environment, the 5%, mean, and 95% probability ranges were found for each sonar specified by URS. The probability ranges were found by calculating the standard deviation and mean values, of each sonar, and assuming a normal distribution. The 95% probability range gives an idea of the mitigation range that could be used when operating different sonars in Australian waters.

DICASS, RASSPUTIN, ASSTASS, SeaBat 6012, MOAS, and Type 2093 sources all had 95% probability ranges less than 1 km for the 160 dB sound pressure level, except the Type 2093 source in VLF mode at full power, which had a range of 1288 m. These sources are expected to have little impact on the Australian marine life, but would still require some environmental mitigation.

A slightly higher range of 2144 m, for 95% probability and 160 dB, was found with the Spherion MFS sonar when operating in an omni directional mode. So this may require a slightly higher mitigation procedure.

The higher powered, low to mid frequency sonars; SQS-56, Mulloka, Spherion B, Spherion MFS (in directional mode), Scylla AA, and LFAS, all had ranges above 4 km at 95% probability and 160 dB sound pressure level, so would require higher mitigation. This could include running TESS II to check the sound pressure levels using at sea data or reducing the source level in sensitive environmental areas. Reducing the source level also reduces the detection range for any submarines, so this could put valuable assets and people at risk. Sonars perform differently depending on the source level, so operators also need to be well trained on how the sonar works at full power.

Contents

1. Introduction

URS Australia is currently writing a document "Environmental Management Plan for Australian Maritime Exercise Areas" to assist the Australian Defence Force (ADF) protect the environment in these exercise areas. Part of this management plan includes looking at the sound pressure levels and sonar frequencies generated by active sources used by the Australian Defence Force (ADF), or possibly to be used in the future, what maximum source levels they produce and what frequencies they use.

To help URS, the Maritime Operations Division (MOD), within DSTO (Defence Science and Technology Organisation), have modelled a number of environments within the Australian maritime exercise areas to determine the expected transmission losses within these areas. Using these transmission loss (TL) curves and indicative maximum source levels produced by these sonars, the expected sound pressure levels were calculated against range from the source. The maximum ranges when the sound pressure level dropped below the limits of 182 and 160 dB were then found, to show what mitigation ranges might be required for the various sonars.

The active sonar frequencies and maximum source levels were supplied by URS and used within TESS II (Tactical Environmental Support Systems) to produce the transmission loss curves. TESS II is currently endorsed by the Navy as its sonar performance prediction tool. RAVE was the numerical model used within TESS II to calculate the transmission loss curves.

2. Active Sonars Studied

The active sonars tested were supplied by URS, along with their source levels and frequencies, table 1.

Table 1: Active sonars tested

System	Indicative Centre Frequency (kHz)	Max. Nominal Source Level (dB re 1 μPa at 1 m)
SSQ-62 (DICASS)	8	202
RASSPUTIN	1.5	205
SQS-56	7.5	230
Mulloka	18	230
Spherion B	6	225
Spherion MFS Omni	8.5	220
Spherion MFS Directional	8.5	230
Scylla AA	10	230
LFAS	0.4	225
ASSTASS	1.6	212
Type 2093 VLF mode	30	220
Type 2093 LF mode	100	220
Type 2093 HF mode	300	230
Type 2093 VHF mode	500	230
MOAS	90	230
Scylla OA	100	220
SeaBat 6012	455	230

3. Environments Used

To determine all the expected transmission losses within Australia's exercise areas would be a massive task, so this was simplified to three representative sites; two within the WAXA and one in the NAXA. The nominal locations were:

- Site 1. Shallow tropical (12°20'S 128°25'E), water depth of 100m
- Site 2. Shallow temperate (33°S 115°E), water depth of 200m
- Site 3. Deep temperate (32°S 112°30'E), water depth of 5000m

These three locations are only nominal to show the variation expected in transmission loss between shallow/deep water and tropical/temperate climates. So the two temperate sites could also be used to represent the EAXA.

The input parameters used in TESS II/RAVE are not from these exact sites. They have been formed by looking at the environmental conditions around each site and showing the variation possible within the general area.

3.1 Sound Speed Profiles

Both summer and winter sound speed profiles (SSP) were used at each site to show the effect of seasons, figures 1 to 4. The sound speed profiles represent the extremes expected, from a summer downward SSP with most of the energy sent towards the seafloor, to a winter surface duct with energy propagating near the surface within the duct and less interaction with the seafloor. The actual SSP values used in RAVE can be seen in Appendix A.

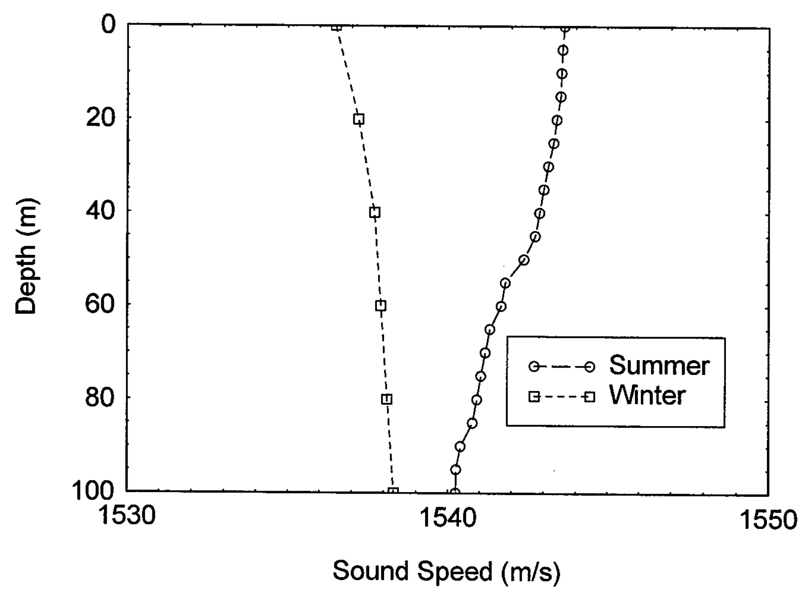

Figure 1: Sound Speed Profile for Site 1, Shallow Tropical

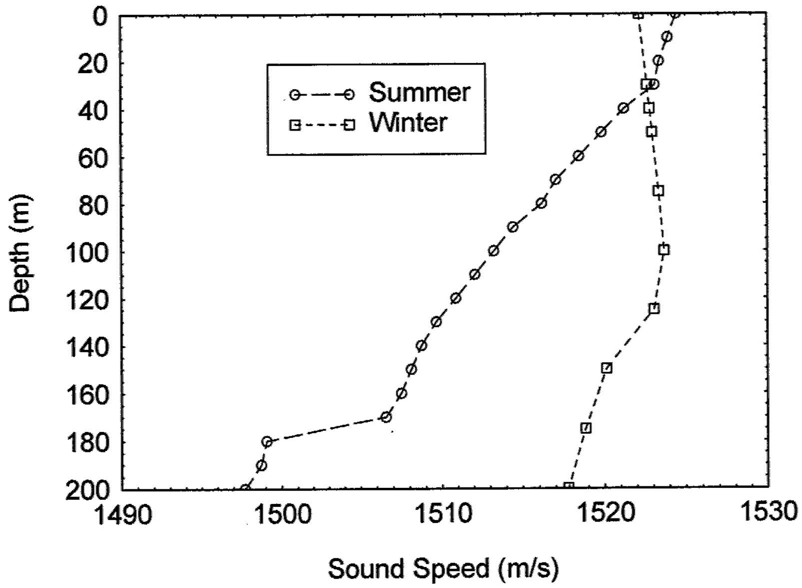

Figure 2: Sound Speed Profile for Site 2, Shallow Temperate

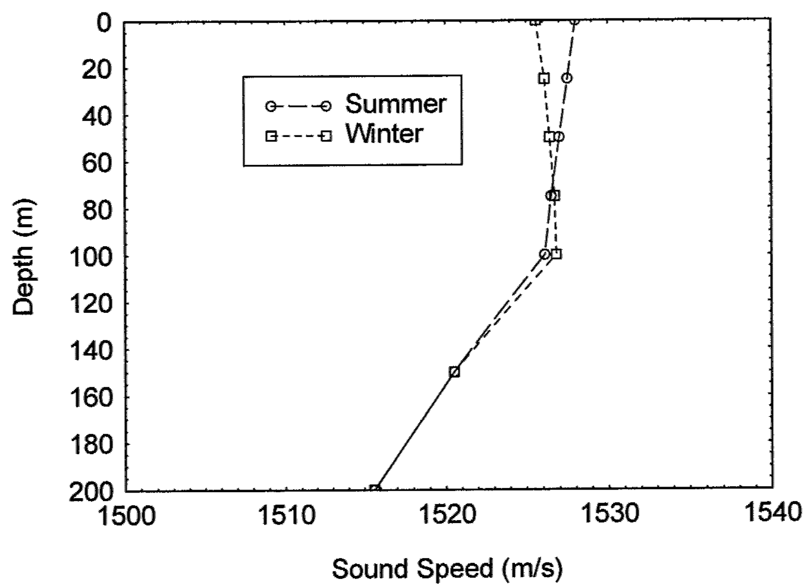

Figure 3: Sound Speed Profile for Site 3, Deep Temperate. Showing only the upper 200 m

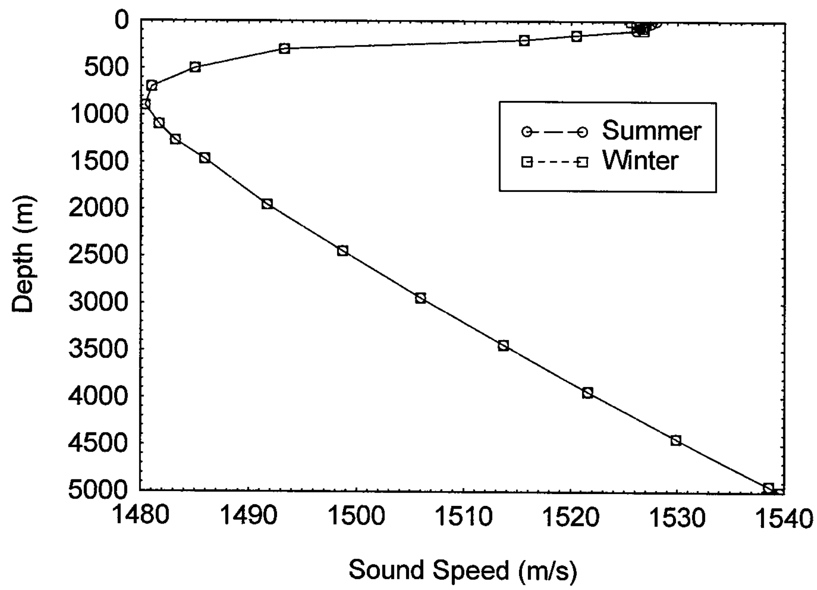

Figure 4: Sound Speed Profile for Site 3, Deep Temperate. The curves overlie for most of the data shown

3.2 Seafloor types

For all sites, three different seafloor geoacoustic profiles were used, representing absorptive, intermediate, and reflective bottom losses. The reflective seafloors should produce the lowest transmission losses, but the others were included to show the variability that could exist.

3.2.1 Reflective

Mean Grain Size = 0.92 phi
Porosity = 34.0 %
Density = ρ = 2077 kg/m^3
Compressional sound speed ratio = c_b/c_w = 1.15
Compressional attenuation = α = 0.519 dB/λ

3.2.2 Intermediate

Mean Grain Size = 5.82 phi
Porosity = 61.3 %
Density = ρ = 1630 kg/m^3
Compressional sound speed ratio = c_b/c_w = 1.026
Compressional attenuation = α = 0.476 dB/λ

3.2.3 Absorptive

Mean Grain Size = 11.0 phi
Porosity = 91.9 %
Density = ρ = 1132 kg/m^3
Compressional sound speed ratio = c_b/c_w = 0.963
Compressional attenuation = α = 0.042 dB/λ

3.3 Wind Speeds

The wind speeds used were 0.5, 2.0, 5.0, 9.0, and 19.0 knots. These correspond to sea states of 0 to 4 and Beaufort winds of 0, 1, 2, 3, and 5. Above sea state four most active sonar operations would cease, so this is the complete range of wind speeds expected during operations.

3.4 Ranges

The transmission loss values were outputted from RAVE in 100 m steps, out to 20 km. Only the first 10 km are displayed, since this is the area of interest.

Since transmission loss calculations were done in 100 m steps, no TL data exists closer than 100 m from the source. DICASS, RASSPUTIN, and ASSTASS sources had a SPL below 182 dB before the 100 m range, but have been marked with 100 m as safe estimates. The spherical spreading estimates would be closer to reality, but since all estimates are extremely close to the source any difference should have minimal effect on any mitigation procedures.

There was no calculation of the sound pressure levels within any convergence zones (CZ) at site 3. To test that no calculations were required, RAVE was run for a worst case scenario; a reflective seafloor, zero sea state, low frequency of 300 Hz, and a summer SSP that directs the energy into the CZ. The first CZ existed at around 60 to 65 km from the source and had a minimum TL of 76 dB. Considering the highest source level tested was 230 dB, this gave a SPL of 154 dB for the worst case (see figure 5), without considering the effect of water absorption, which would reduce the SPL even more. The next CZ would exist around 120 km from the source and have an even lower SPL.

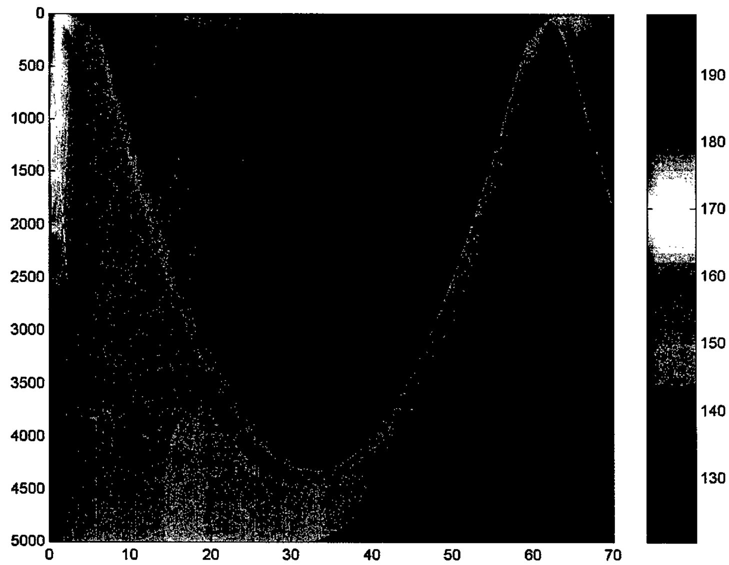

Figure 5: Convergence Zone Sound Pressure Levels for a worst-case scenario. The colour bar on the right shows the sound pressure levels for a 230 dB source level

3.5 Depths

The depth spacing used depended on the site. For sites 1 and 2, 200 depth points were used giving a depth spacing of 0.5 m and 1 m, respectively. For site 3, 2500 depth points were used giving a depth spacing of 2 m.

3.6 Source Depth

Most of the active sources considered were hull mounted and were given a nominal depth of 7 m below the sea surface when modelling. The two exceptions were the sonobuoys; the DICASS sonobuoy had the source at 27 m, while the RASSPUTIN sonobuoy had the source at 23 m.

3.7 Remaining Environmental Inputs

The following inputs remained the same for each RAVE run.

Maximum range calculated= 20 km
Pulse length = 0.5 sec
Volume scattering parameter = -85.2 dB
Omni directional source and receiver
Range independent modelling

4. Obtaining Sound Pressure Levels

The transmission losses produced by RAVE (see Appendix B) were then used to calculate the sound pressure levels (see Appendix C) out to 20 km for each sonar frequency and environmental condition. An energy average of the top 100 m of the water column was used, instead of a single depth value, to give a better estimation of the SPL any marine life would be experiencing. For site 1, this included the whole water column.

Sound pressure levels were calculated using:

SPL = SL + TL [1]

where SPL = average sound pressure level in the top 100 m of water
SL = maximum source level of the sonar being tested
TL = average transmission loss calculated using RAVE

The maximum range any calculated SPL were above the SPL limits of 182 dB and 160 dB[2] were then found, with a linear curve fit done between the 100 m RAVE range steps to find the actual range of each crossing.

For each sonar, the combinations of three sites, two seasons, three seafloor types, and five wind speeds resulted in 90 range values for each SPL limit. The standard deviation in range was then found for each sonar and a 95% probability limit calculated, assuming a normal distribution. Where the 95% probability limit = 1.65 standard deviations past the mean range. All the SPL curves are shown in Appendix C, along with the 182 and 160 dB SPL limits.

---

[1] Normally SPL=SL-TL but since RAVE outputs TL as a negative number this was changed to SPL=SL+TL.

[2] The 182 and 160 dB SPL limits were supplied by URS for this study.

5. Range Predicted for Each Sonar

The ranges calculated, using RAVE, for each sonar are displayed in table 2. The mean, 95%, and 5% probability limits are shown. The 95% probability limit gives a good idea of what mitigation range should be used, while the mean and 5% give an idea of the variations that could exist around Australia. The plots of SPL verse range used to obtain these results can be seen in Appendix C.

Table 2: Ranges Calculated using RAVE for each sonar

System	Indicative Centre Frequency (kHz)	Max. Nominal Source Level (dB re 1 μPa at 1 m)	Distance from Source to 182 dB (m)			Distance from Source to 160 dB (m)		
			5%	mean	95%	5%	mean	95%
SSQ-62 (DICASS)	8	202	[redacted]	[redacted]	[redacted]	278	286	295
RASSPUTIN	1.5	205	[redacted]	[redacted]	[redacted]	326	347	368
SQS-56	7.5	230	363	421	479	2374	[redacted]	[redacted]
Mulloka	18	230	357	409	461	2003	3245	[redacted]
Spherion B	6	225	287	302	316	1587	2947	[redacted]
Spherion MFS Omni	8.5	220	224	235	246	897	1521	2144
Spherion MFS Directional	8.5	230	362	420	478	2308	[redacted]	[redacted]
Scylla AA	10	230	361	418	476	2299	[redacted]	[redacted]
LFAS	0.4	225	292	303	313	1847	3082	[redacted]
ASSTASS	1.6	212	[redacted]	[redacted]	[redacted]	482	615	748
Type 2093 VLF mode	30	220	220	231	242	762	1025	1288
Type 2093 LF mode	100	220	201	214	228	462	487	513
Type 2093 HF mode	300	230	237	249	261	376	394	412
Type 2093 VHF mode	500	230	207	217	226	317	332	348
MOAS	90	230	311	328	346	695	750	805
Scylla OA	100	220	201	214	228	462	487	513
SeaBat 6012	455	230	215	224	233	328	345	361

The ranges calculated at a SPL of 182 dB for DICASS, RASSPUTIN, and ASSTASS sources are all 100 m (shown in green), this was because RAVE only calculated the TL values in 100 m steps, so the SPL was already below 182 dB at 100 m for all environmental conditions used. Spherical spreading + absorption gave a better estimate of the ranges when the SPL dropped below 182 dB for these three cases (see table 3), since the ranges were so small. This gave ranges of 10, 14, and 32 m for the DICASS, RASSPUTIN, and ASSTASS sources, respectfully.

The values shown in red are for ranges above 4 km, these are significant since it is difficult to do visual mitigation of whales past 4 km on surface ships. All environmental conditions when any range was calculated above 4 km have been listed in tables 4 to 9.

A comparison of the ranges found using spherical spreading (table 3), or spherical spreading + absorption for the higher frequencies, with RAVE (table 2), showed that in most circumstances spherical spreading was under estimating the ranges, so this should not be used as a rough estimate, unless the ranges expected are very small.

Table 3: Ranges Calculated using spherical spreading for each sonar. Absorption values obtained from Urick, Principals of Underwater Sound

System	Indicative Centre Frequency (kHz)	Max. Nominal Source Level (dB re 1 μPa at 1 m)	Spherical comparison		Absorption (dB/km)	Spherical + Absorption comparison	
			182	160		182	160
SSQ-62 (DICASS)	8	202	10	126	0.35	10	125
RASSPUTIN	1.5	205	14	178	0.07	14	178
SQS-56	7.5	230	251	3162	0.34	249	2831
Mulloka	18	230	251	3162	1.2	243	2300
Spherion B	6	225	141	1778	0.27	141	1686
Spherion MFS Omni	8.5	220	79	1000	3.9	76	721
Spherion MFS Directional	8.5	230	251	3162	3.9	200	1560
Scylla AA	10	230	251	3162	0.44	248	2753
LFAS	0.4	225	141	1778	0.01	141	1774
ASSTASS	1.6	212	32	398	0.07	32	397
Type 2093 VLF mode	30	220	79	1000	3.1	77	764
Type 2093 LF mode	100	220	79	1000	24	66	364
Type 2093 HF mode	300	230	251	3162	66	110	308
Type 2093 VHF mode	500	230	251	3162	109	86	214
MOAS	90	230	251	3162	22	165	637
Scylla OA	100	220	79	1000	24	66	364
SeaBat 6012	455	230	251	3162	93	93	241

5.1 Long Range Conditions

Environmental conditions where the ranges calculated using RAVE were above 4 km at 160 dB are shown below (tables 4 to 9). These represent conditions where using visual sightings from ships to observe whale blows would be difficult. These also show where more stringent mitigation procedures or reductions in source levels could be used.

The sonars that have this long range are the high powered, 225 to 230 dB, sonars with a frequency below 10 kHz. Above 10 kHz is normally used by minehunting sonars and torpedos, where long range is not important and water absorption reduces the SPL at longer ranges (see table 3 for absorption levels). Reducing the source level can have a significant reduction in the SPL at long ranges (see Appendix C.1.), but this can also reduce the detection range of enemy submarines by similar amounts.

Higher SPL at longer ranges occur with environmental conditions like low sea state, reflective seafloors in shallow water, and surface ducts, with a combination of these giving even higher values.

5.1.1 SQS-56

Table 4: Environmental conditions resulting in a range above 4 km at 160 dB for SSQ-56

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	abs	0 to 2
site1	summer	int	0 to 4
site1	summer	ref	0 to 4
site1	winter	abs	0 to 3
site1	winter	int	0 to 3
site1	winter	ref	0 to 3
site2	summer	int	0 to 3
site2	summer	ref	0 to 4
site2	winter	abs	0 to 3
site2	winter	int	0 to 4
site2	winter	ref	0 to 4
site3	winter	abs	0 to 3
site3	winter	int	0 to 3
site3	winter	ref	0 to 3

5.1.2 Mulloka

Table 5: Environmental conditions resulting in a range above 4 km at 160 dB for Mulloka

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	int	0 to 2
site1	summer	ref	0 to 2
site1	winter	int	0 to 2
site1	winter	ref	0 to 2
site2	summer	ref	0 to 2
site2	winter	ref	0 to 2

5.1.3 Spherion B

Table 6: Environmental conditions resulting in a range above 4 km at 160 dB for Spherion B

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	int	0 to 1
site1	summer	ref	0 to 3
site1	winter	int	0 to 1
site1	winter	ref	0 to 2
site2	summer	ref	0 to 2
site2	winter	ref	0 to 2

5.1.4 Spherion MFS Directional

Table 7: Environmental conditions resulting in a range above 4 km at 160 dB for Spherion MFS Directional

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	abs	0
site1	summer	int	0 to 4
site1	summer	ref	0 to 4
site1	winter	abs	0 to 3
site1	winter	int	0 to 3
site1	winter	ref	0 to 3
site2	summer	int	0 to 3
site2	summer	ref	0 to 4
site2	winter	abs	0 to 3
site2	winter	int	0 to 4
site2	winter	ref	0 to 4
site3	winter	abs	0 to 3
site3	winter	int	0 to 3
site3	winter	ref	0 to 3

5.1.5 Scylla AA

Table 8: Environmental conditions resulting in a range above 4 km at 160 dB for Scylla AA

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	int	0 to 4
site1	summer	ref	0 to 4
site1	winter	abs	0 to 3
site1	winter	int	0 to 3
site1	winter	ref	0 to 3
site2	summer	int	0 to 3
site2	summer	ref	0 to 4
site2	winter	abs	0 to 3
site2	winter	int	0 to 4
site2	winter	ref	0 to 4
site3	winter	abs	0 to 2
site3	winter	int	0 to 2
site3	winter	ref	0 to 2

5.1.6 LFAS

Table 9: Environmental conditions resulting in a range above 4 km at 160 dB for LFAS

Site	Season	Seafloor Reflectivity	Sea State
site1	summer	ref	0 to 4
site1	winter	ref	0 to 3
site2	winter	ref	0 to 4

6. Conclusions

The sound pressure levels were calculated for 90 different environmental conditions around Australia using TESS II, for each sonar type at maximum nominal source power. The maximum ranges for sound pressure levels of 182 and 160 dB were then calculated (see Appendix C). Since these ranges varied depending upon environmental conditions, the 5%, mean, and 95% probability ranges were calculated, assuming a normal distribution. These ranges are displayed in table 2.

Most of the sonars had a reasonable 95% range at the 160 dB sound pressure level, but the high powered, 225 to 230 dB, low to mid frequency sonars had a significantly greater range (shown in red on table 2). Higher mitigation procedures should be used when operating these sonars, especially in low sea states and within surface ducts. This could include running TESS II to check the sound pressure levels using at sea data or reducing the source level (see Appendix C1) in sensitive environmental areas.

Reducing the source level also reduces the detection range for any submarines, since this is the main purpose for operating these sonars, running them at a lower source level for all non-combat exercises could put valuable assets and people at risk. The sonars perform differently depending on the source level, so the operator needs to be well trained on how the sonar will work at full power.

7. Acknowledgements

I would like to acknowledge the help of the following people for this report:

- John Polglaze from URS for supplying the sonar types, indicative frequencies, and nominal source levels. Along with the 182 and 160 dB sound pressure thresholds.
- Jarrad Exelby from MOD, DSTO for help using TESS II and RAVE.

8. References

Robert J. Urick, Principles of Underwater Sound 3rd Edition, Los Altos California, Peninsula Publishing

Appendix A: Sound Speed Profiles

The following tables show the values used for each sound speed profile.

Table 10: Shallow Tropical, Summer SSP

Depth, m	Sound Speed, m/s
0	1543.64
5	1543.58
10	1543.55
15	1543.52
20	1543.4
25	1543.3
30	1543.14
35	1543
40	1542.87
45	1542.74
50	1542.39
55	1541.81
60	1541.68
65	1541.32
70	1541.18
75	1541.04
80	1540.91
85	1540.77
90	1540.39
95	1540.25
100	1540.24

Table 11: Shallow Tropical, Winter SSP

Depth, m	Sound Speed, m/s
0	1536.5
20	1537.2
40	1537.7
60	1537.9
80	1538.1
100	1538.3

Table 12: Shallow Temperate, Summer SSP

Depth, m	Sound Speed, m/s
0	1524.45
10	1523.92
20	1523.39
30	1523.13
40	1521.23
50	1519.85
60	1518.45
70	1517.03
80	1516.17
90	1514.43
100	1513.25
110	1512.06
120	1510.86
130	1509.64
140	1508.72
150	1508.11
160	1507.5
170	1506.56
180	1499.06
190	1498.73
200	1497.72

Table 13: Shallow Temperate, Winter

Depth, m	Sound Speed, m/s
0	1522.17
30	1522.65
40	1522.8
50	1522.97
75	1523.36
100	1523.68
125	1523.06
150	1520.12
175	1518.82
200	1517.76

Table 14: Deep Temperate, Summer

Depth, m	Sound Speed, m/s
0	1528
25	1527.5
50	1527
75	1526.5
100	1526.1
150	1520.5
200	1515.6
300	1493.3
500	1485
698	1481
896	1480.4
1094	1481.7
1266	1483.2
1463	1485.9
1955	1491.7
2448	1498.7
2944	1506
3442	1513.7
3940	1521.6
4440	1529.9
4940	1538.6
5000	1539.6

Table 15: Deep Temperate, Winter

Depth, m	Sound Speed, m/s
0	1525.6
25	1526.1
50	1526.4
75	1526.7
100	1526.8
150	1520.5
200	1515.6
300	1493.3
500	1485
698	1481
896	1480.4
1094	1481.7
1266	1483.2
1463	1485.9
1955	1491.7
2448	1498.7
2944	1506
3442	1513.7
3940	1521.6
4440	1529.9
4940	1538.6
5000	1539.6

Appendix B: Transmission Loss Plots

The following plots (figure 6 to 22) show the transmission loss results produced for the 90 different environmental conditions for each sonar. The plots vary depending on the frequencies used by the sonars. The sound pressure levels produced by each sonar, when operating at maximum nominal power, are shown in Appendix C. The ranges were calculated to 20 km, but only the first 10 km are shown in the plots since this is the area of interest.

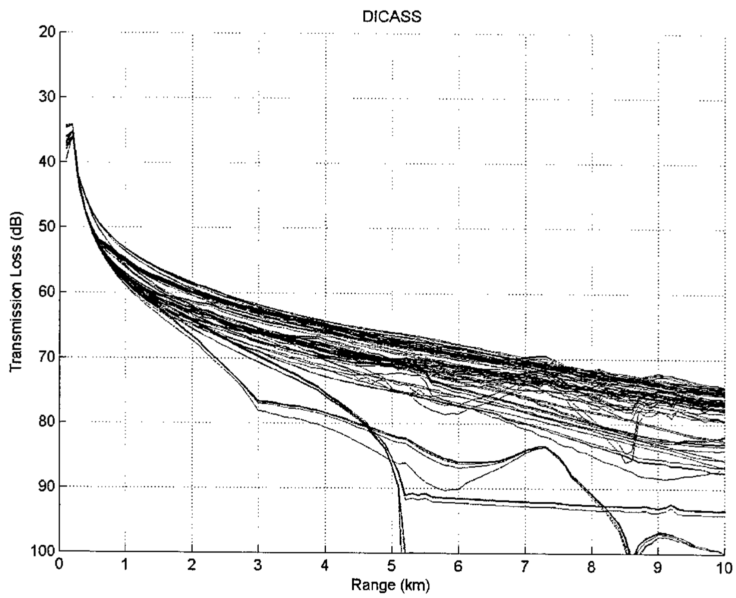

Figure 6: Transmission loss vs range for the DICASS source

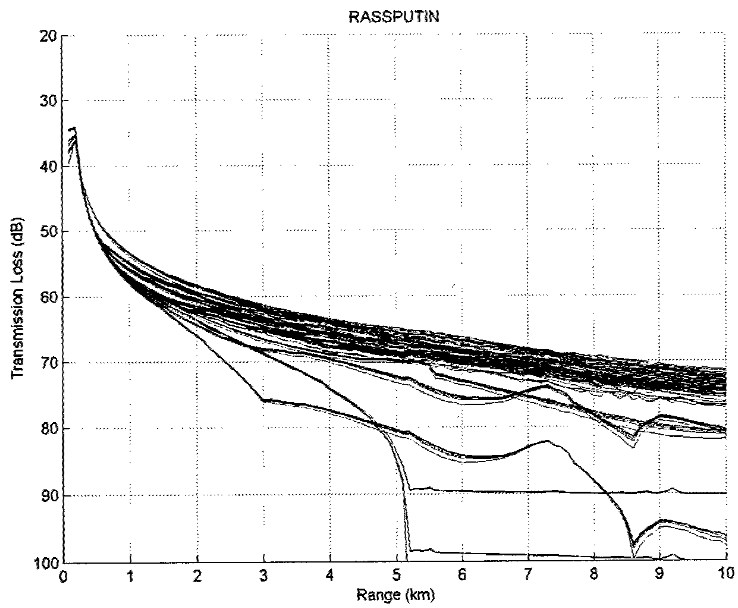

Figure 7: Transmission loss vs range for the RASSPUTIN source

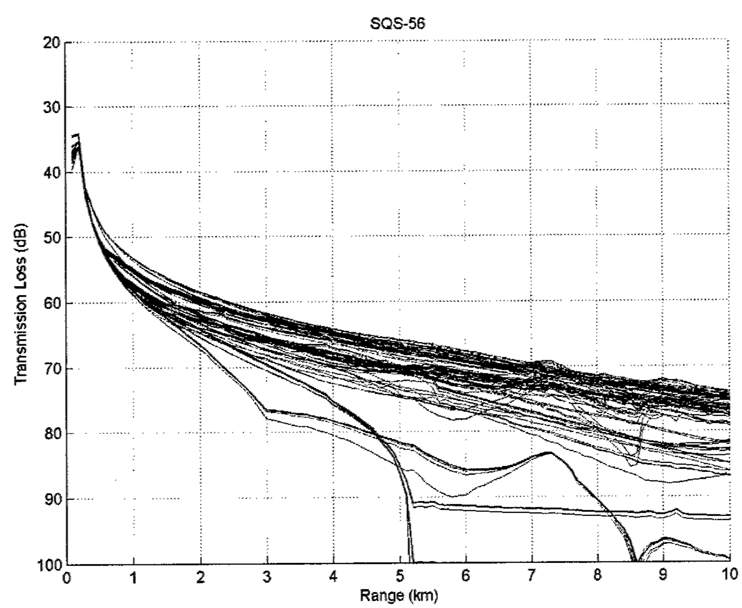

Figure 8: Transmission loss vs range for the SQS-56 source

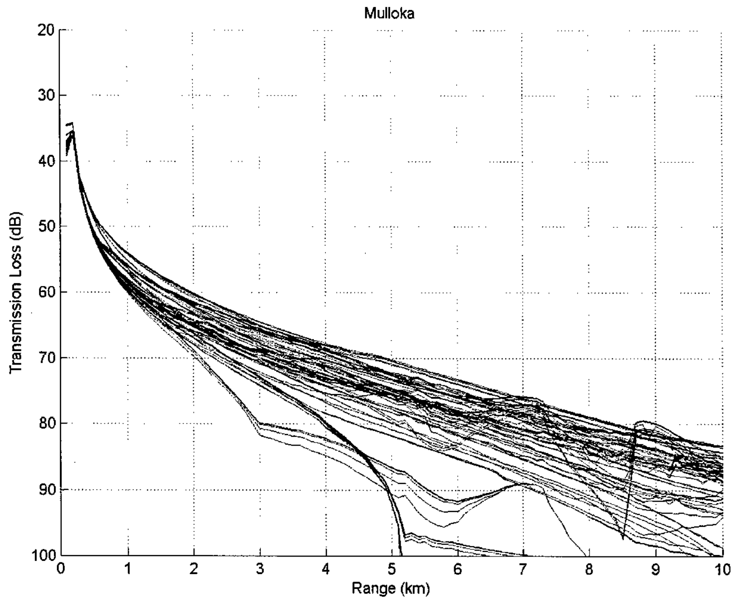

Figure 9: Transmission loss vs range for the Mulloka source

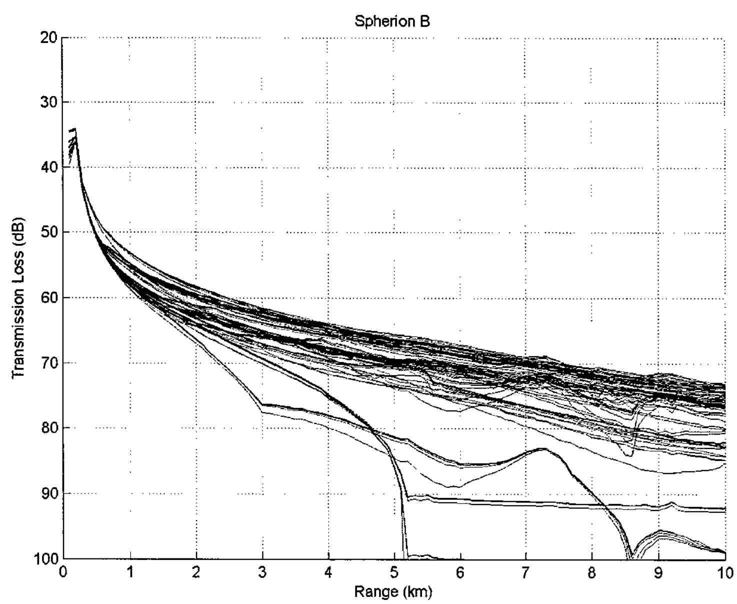

Figure 10: Transmission loss vs range for the Spherion B source

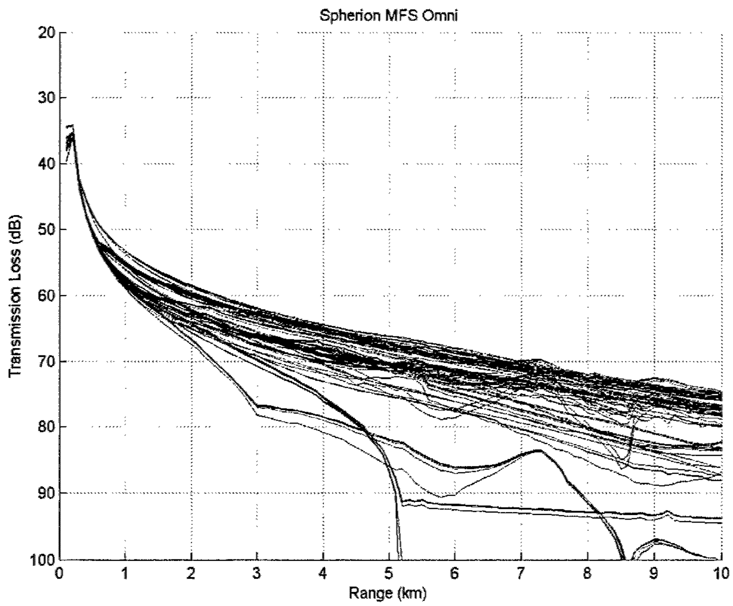

Figure 11: Transmission loss vs range for the Spherion MFS Omni source

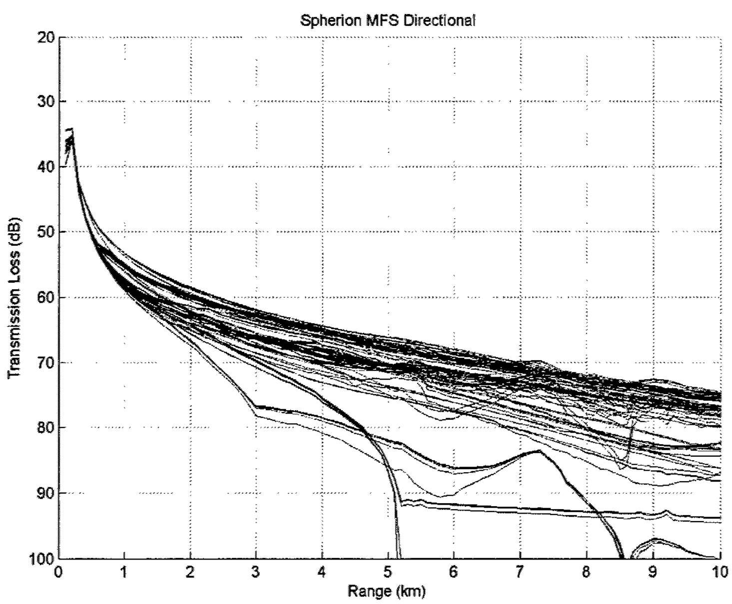

Figure 12: Transmission loss vs range for the Spherion MFS Directional source

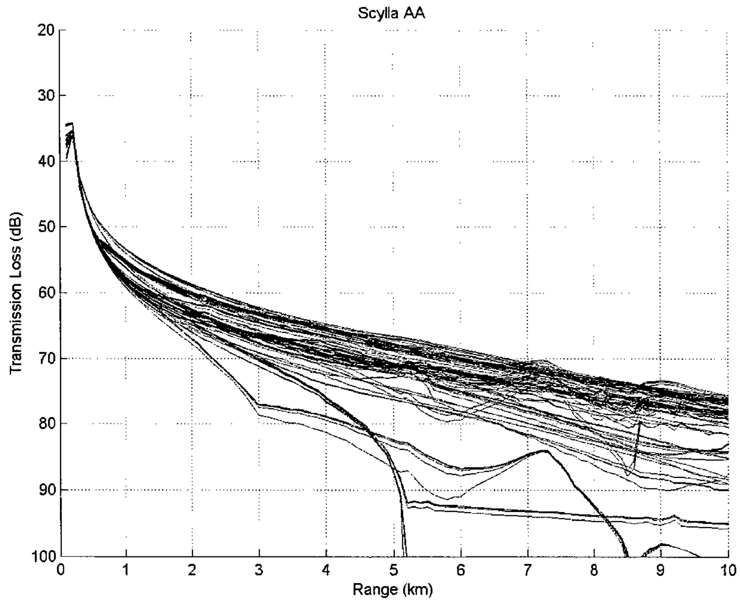

Figure 13: Transmission loss vs range for the Scylla AA source

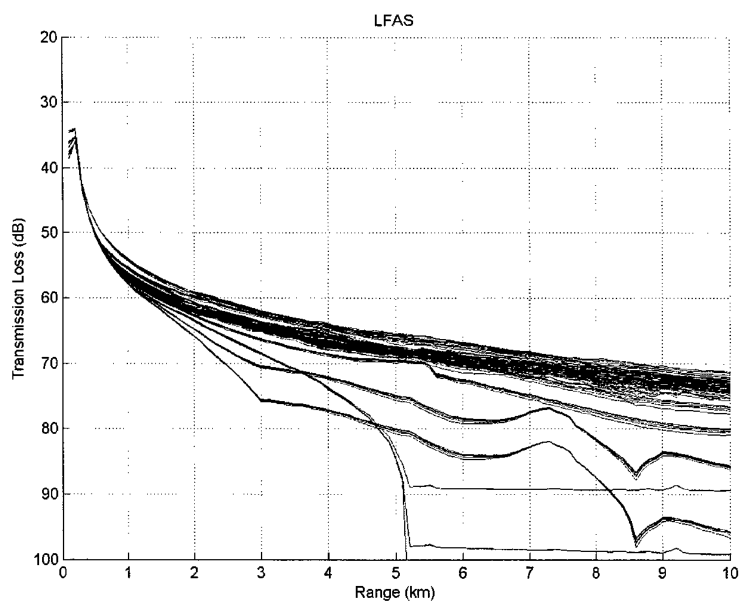

Figure 14: Transmission loss vs range for the LFAS source

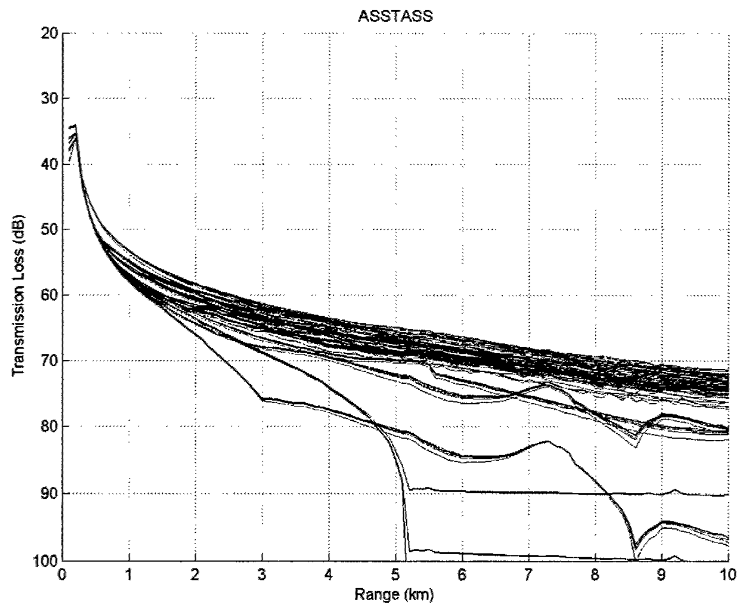

Figure 15: Transmission loss vs range for the ASSTASS source

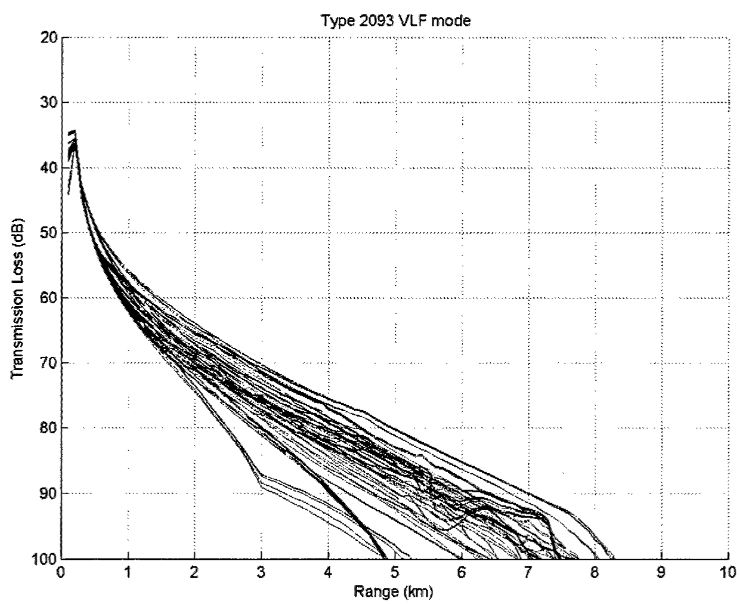

Figure 16: Transmission loss vs range for the 2093 VLF source

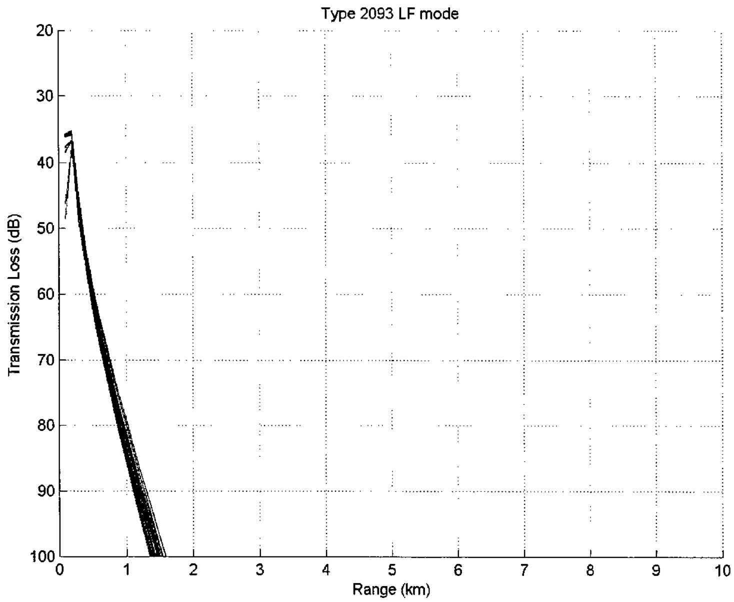

Figure 17: Transmission loss vs range for the 2093 LF source

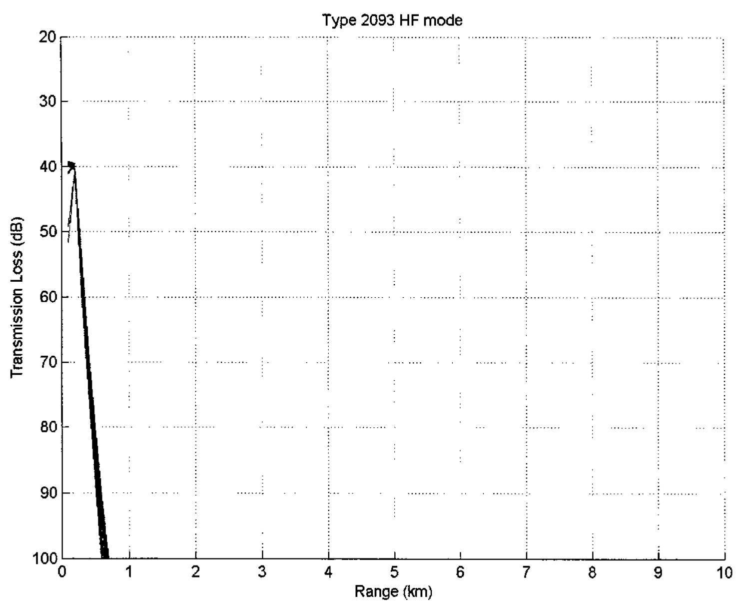

Figure 18: Transmission loss vs range for the 2093 HF source

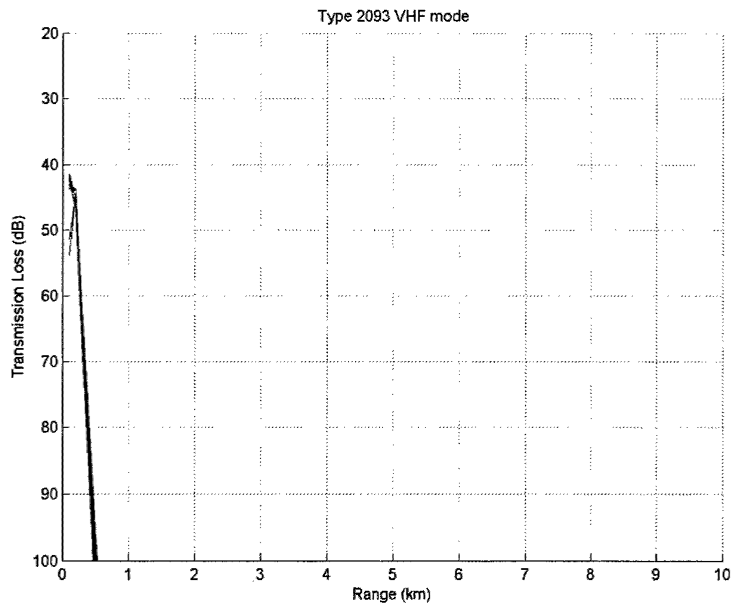

Figure 19: Transmission loss vs range for the 2093 VHF source

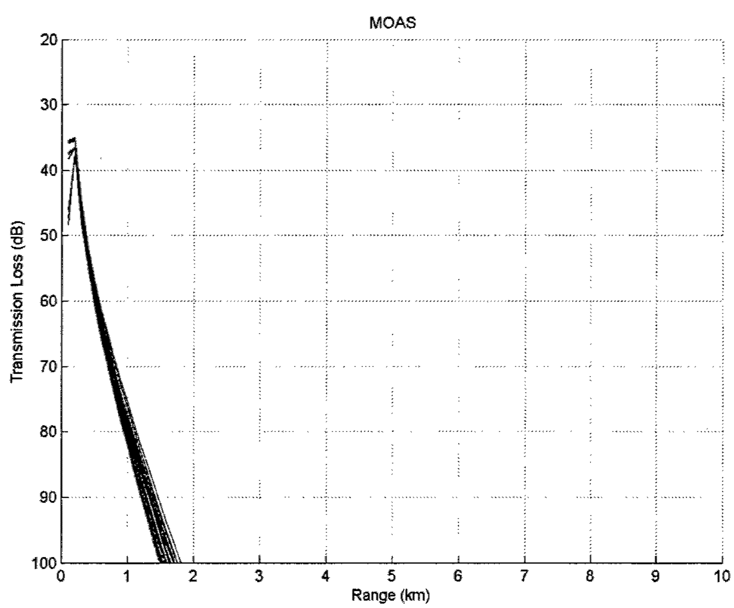

Figure 20: Transmission loss vs range for the MOAS source

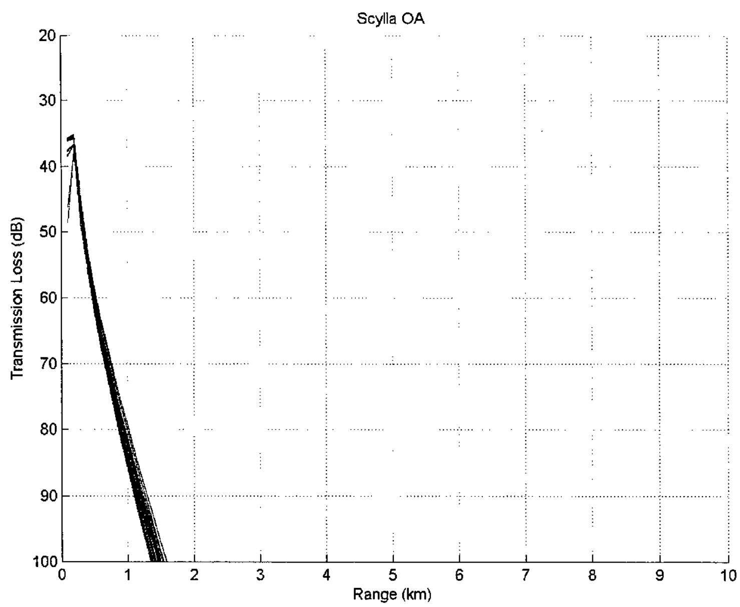

Figure 21: Transmission loss vs range for the Scylla OA source

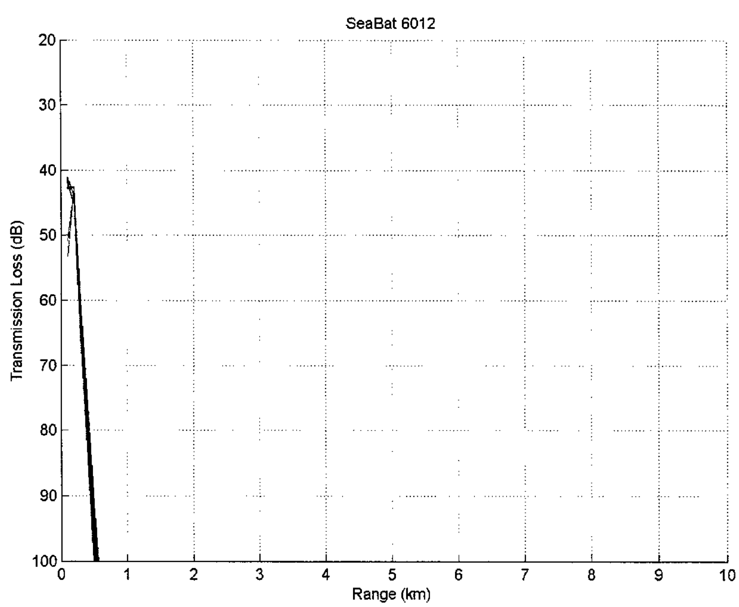

Figure 22: Transmission loss vs range for the SeaBat 6012 source

Appendix C: Sound Pressure Plots

The following plots (figure 23 to 39) show the sound pressure levels calculated for each sonar, operating at maximum nominal source level, with all the different environmental conditions. The plots vary depending on the frequencies and maximum source levels used by the sonars. The ranges were calculated to 20 km, but only the first 10 km are shown in the plots since this is the area of interest. The 182 and 160 dB SPL levels have been highlighted since these are the sound pressure limits used in tables 2 and 3.

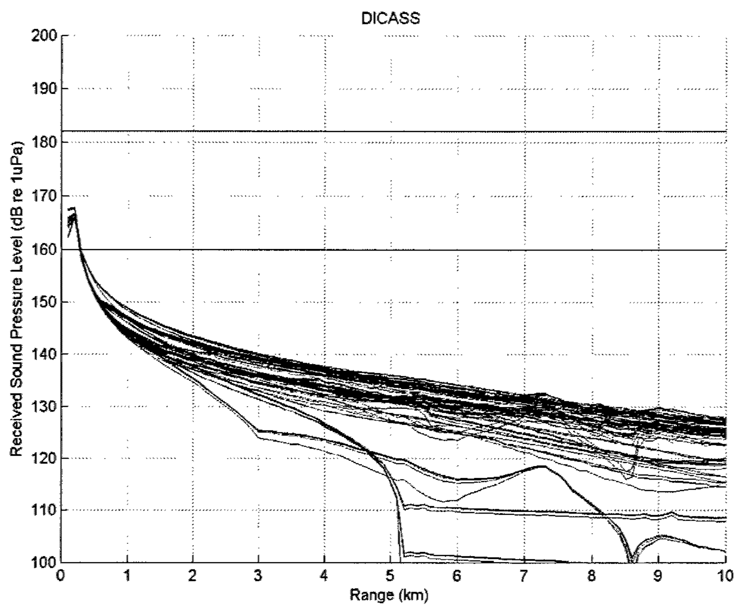

Figure 23: Sound pressure level vs range for the DICASS source

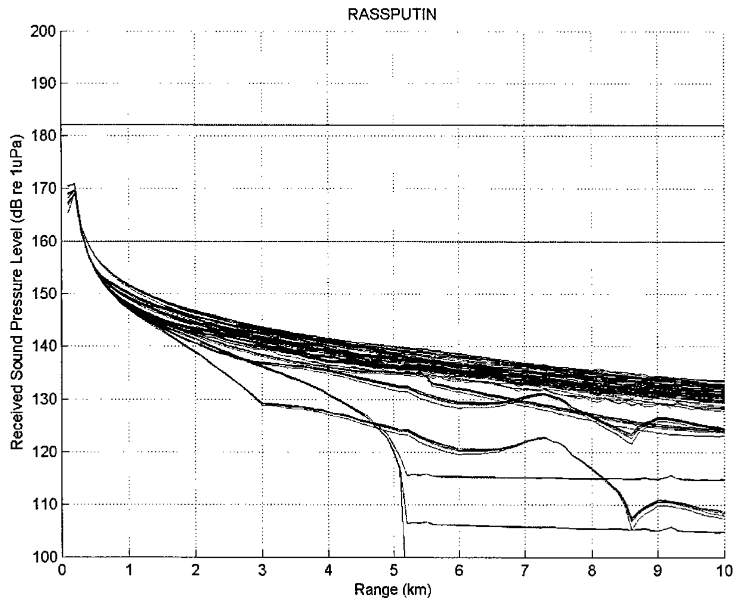

Figure 24: Sound pressure level vs range for the RASSPUTIN source

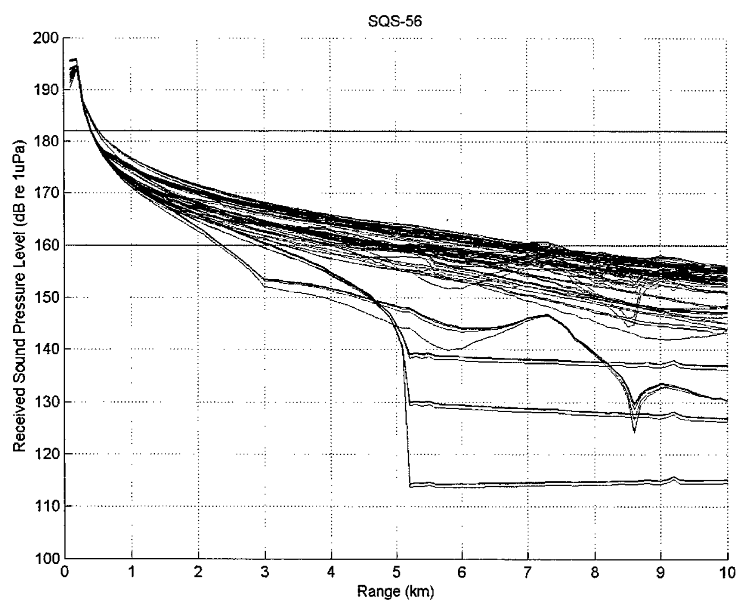

Figure 25: Sound pressure level vs range for the SQS-56 source

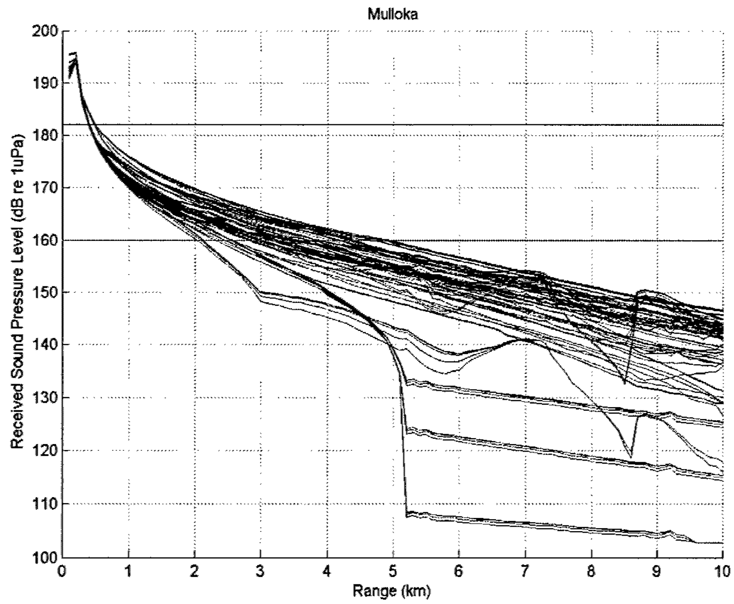

Figure 26: Sound pressure level vs range for the Mulloka source

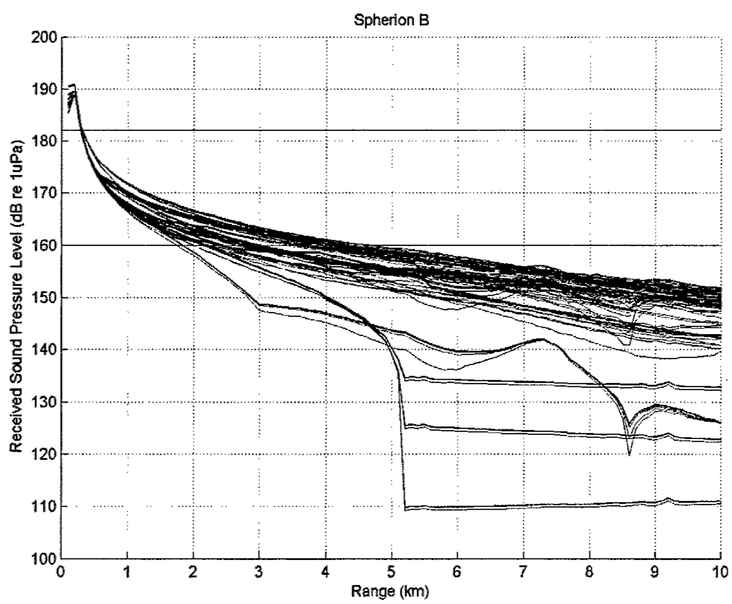

Figure 27: Sound pressure level vs range for the Spherion B source

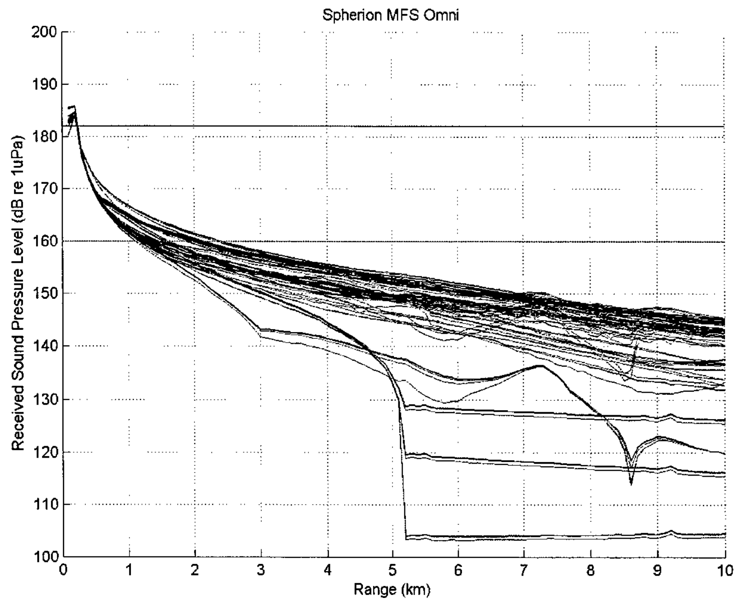

Figure 28: Sound pressure level vs range for the Spherion MFS Omni source

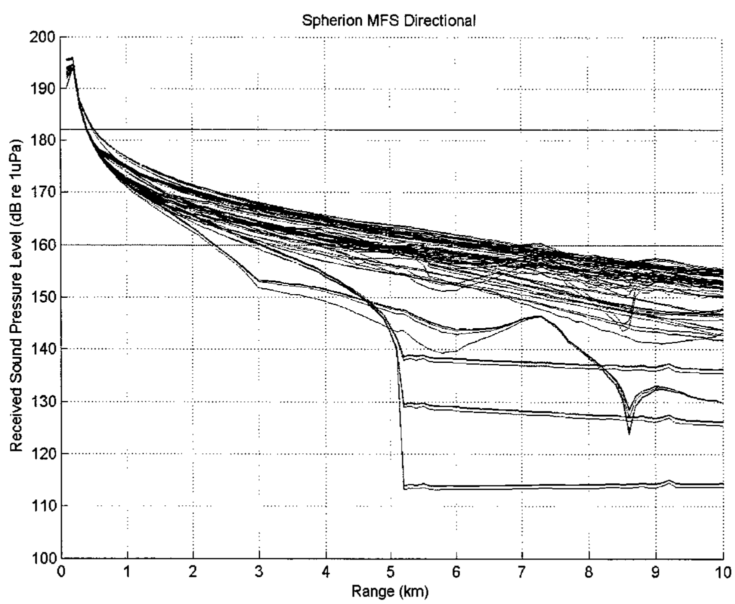

Figure 29: Sound pressure level vs range for the Spherion MFS Directional source

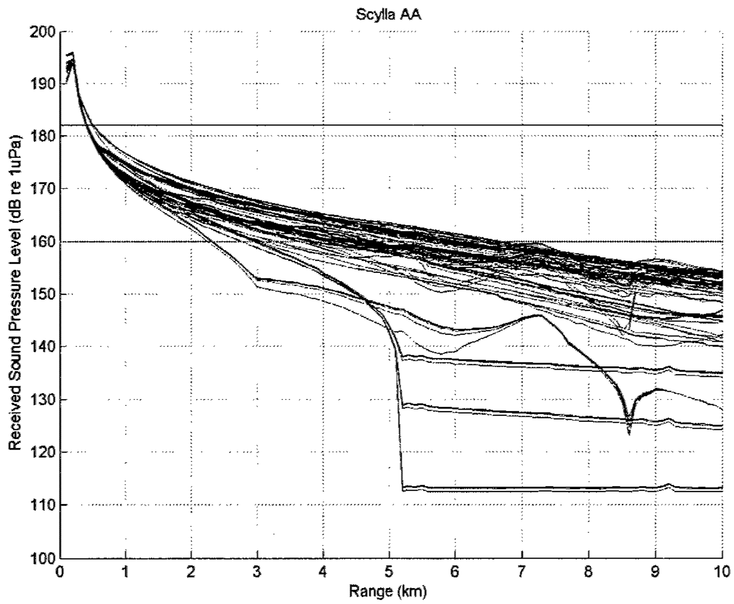

Figure 30: Sound pressure level vs range for the Scylla AA source

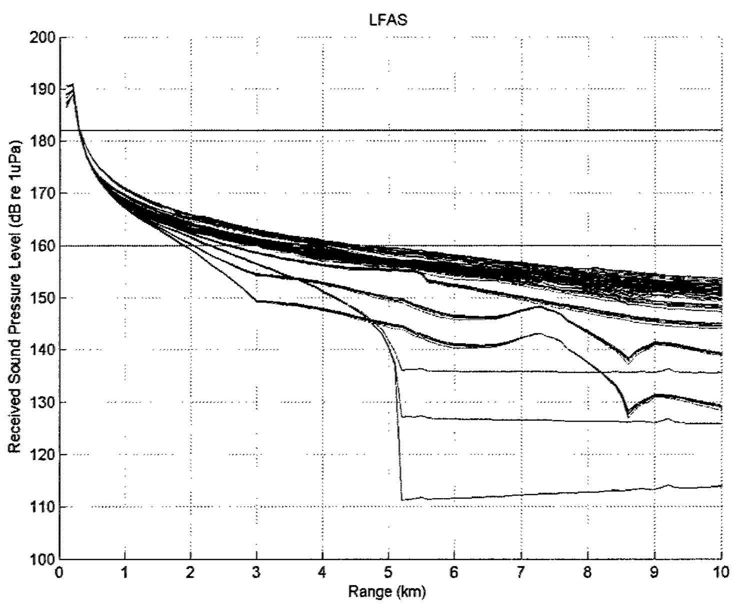

Figure 31: Sound pressure level vs range for the LFAS source

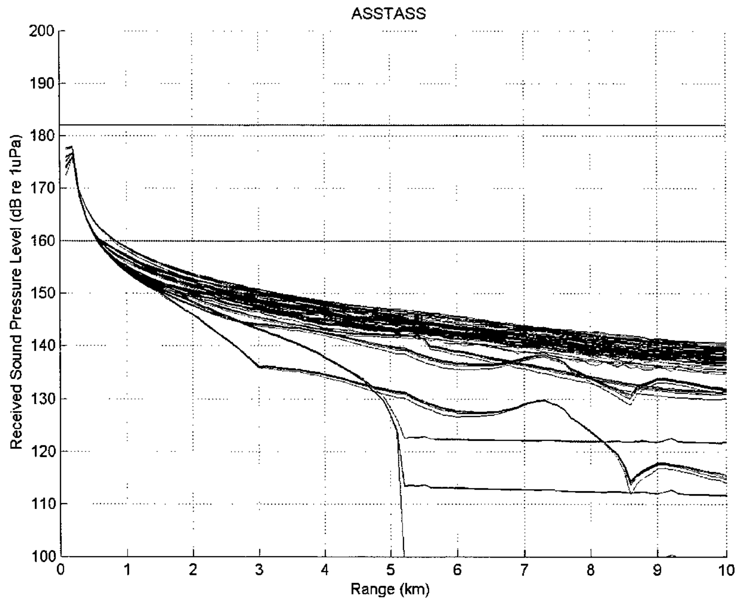

Figure 32: Sound pressure level vs range for the ASSTASS source

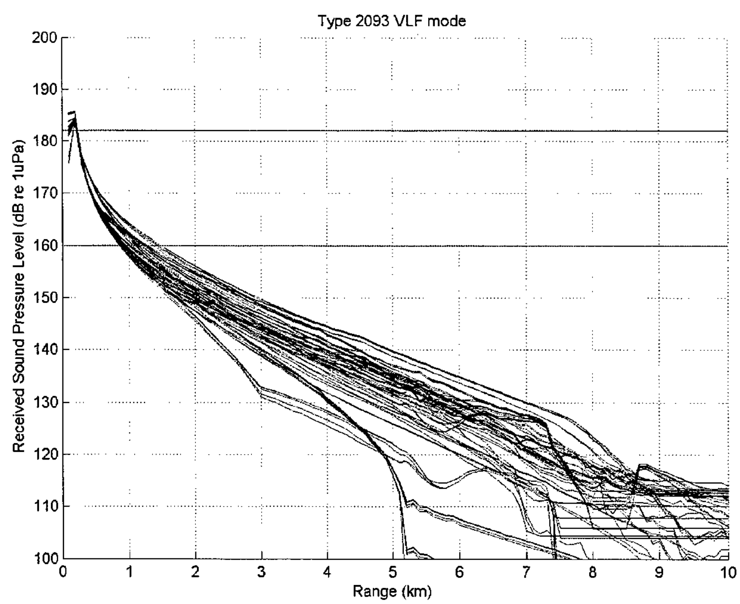

Figure 33: Sound pressure level vs range for the 2093 VLF source

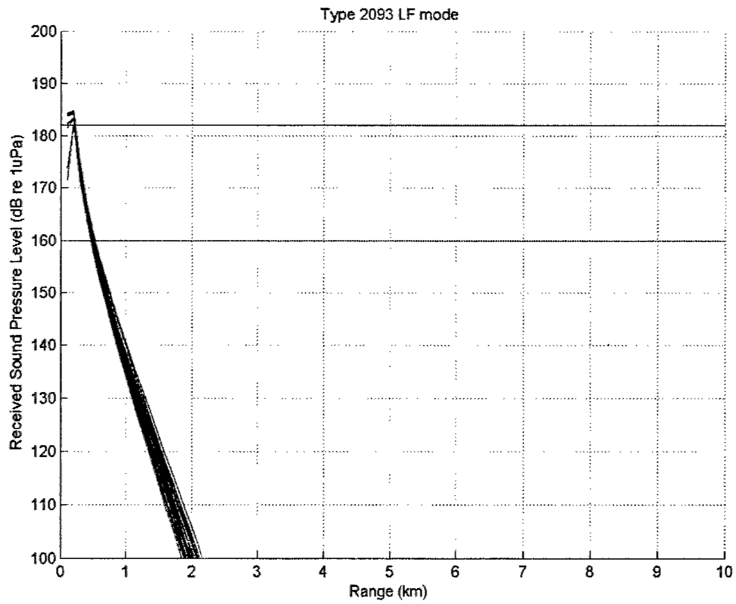

Figure 34: Sound pressure level vs range for the 2093 LF source

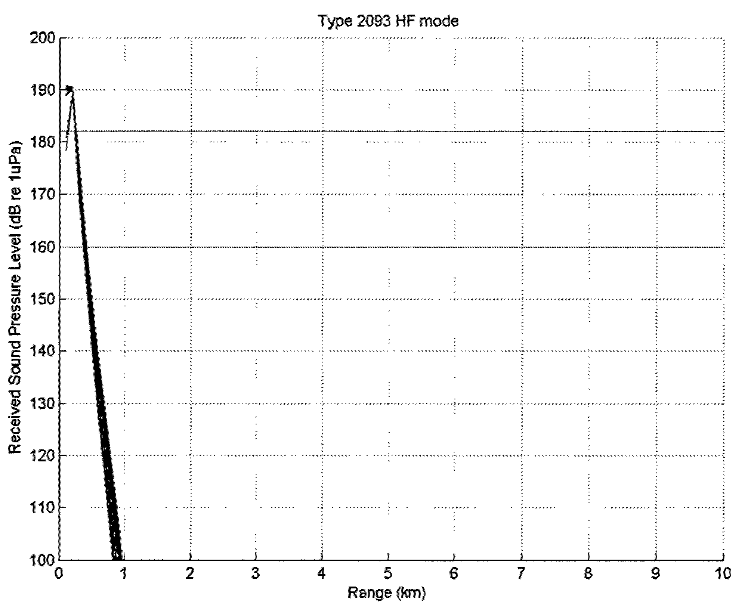

Figure 35: Sound pressure level vs range for the 2093 HF source

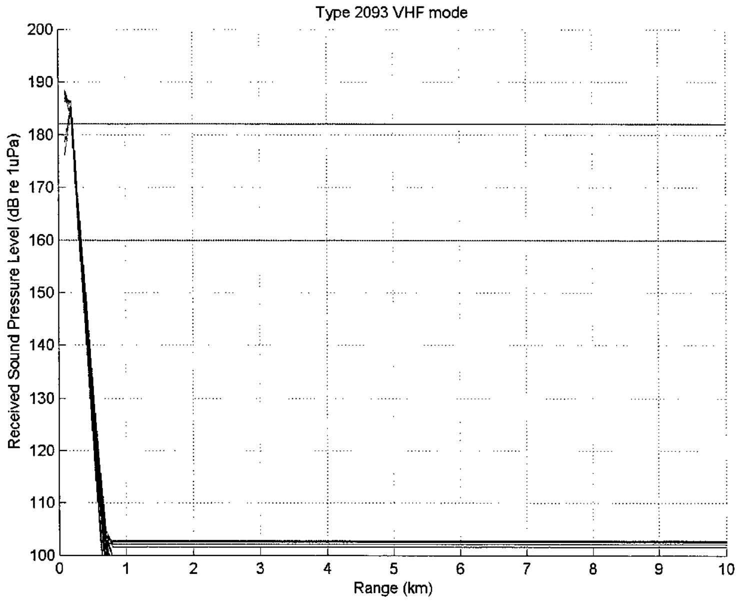

Figure 36: Sound pressure level vs range for the 2093 VHF source

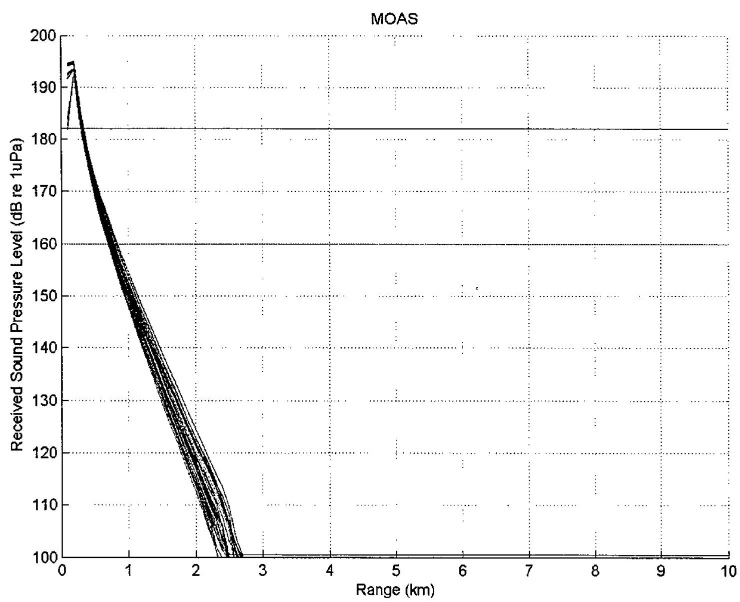

Figure 37: Sound pressure level vs range for the MOAS source

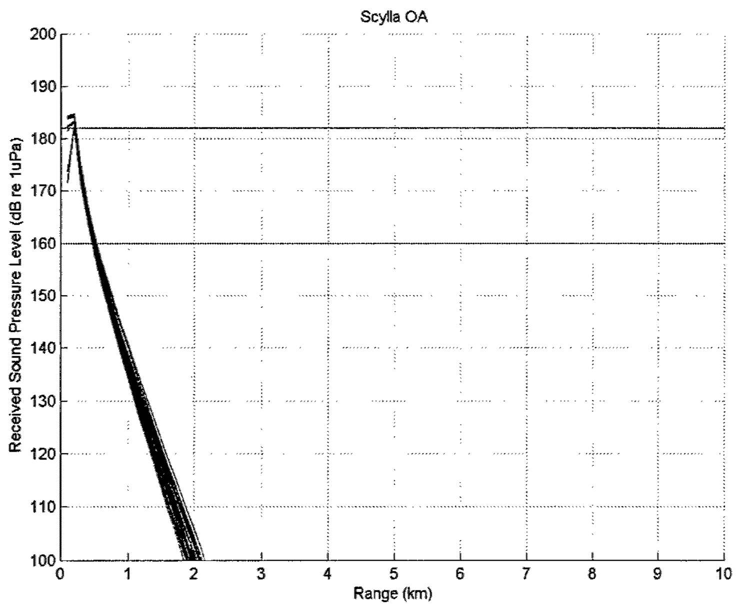

Figure 38: Sound pressure level vs range for the Scylla OA source

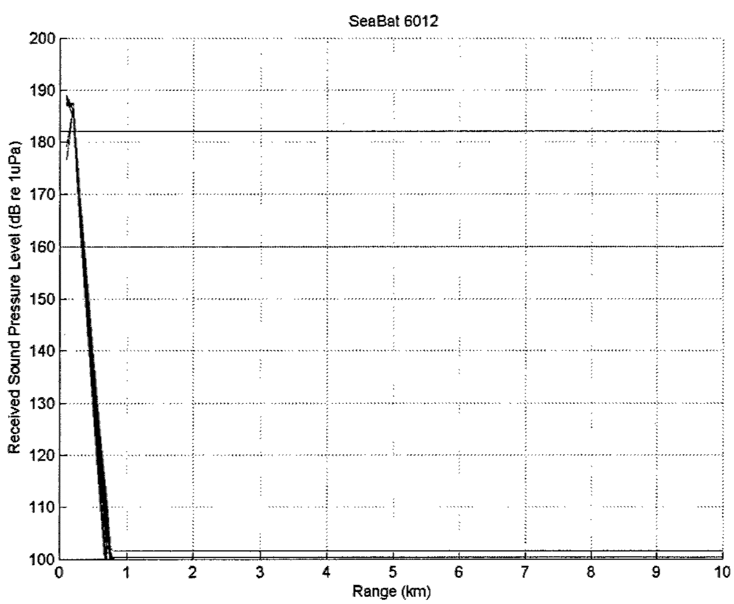

Figure 39: Sound pressure level vs range for the SeaBat 6012 source

C.1. Reducing Source Level

Reducing the source level of a sonar can have a significant reduction in the SPL received at long ranges. This is due to the SPL reducing at a slower rate from spreading losses at long range, similar to cylindrical spreading, compared to spherical spreading at close ranges. The higher frequency sonars would have less range variation since water absorption is causing the attenuation. Also, lower powered sonars would have less benefit since their mitigation ranges are around the spherical spreading region, so spreading losses are still significant.

The reduction in source level does have a major drawback; the detection range of any enemy submarine is also reduced by a similar amount putting valuable assets and people at risk. So reducing the source level should only be used when the maximum source level is not required or in sensitive environmental areas.

The effect of reducing the source level can be seen using figures 23 to 39. For a 5 dB reduction in the source level, the received sound pressure curves will also drop by 5 dB reducing the range a 160 dB SPL is heard.

As an example, consider the Spherion B sonar, which had a long range before the SPL dropped below 160 dB. For a 5 dB reduction in source level the 95% range has reduced from 4.3 km to 2.2 km (see figures 27 and 40) at the 160 dB level.

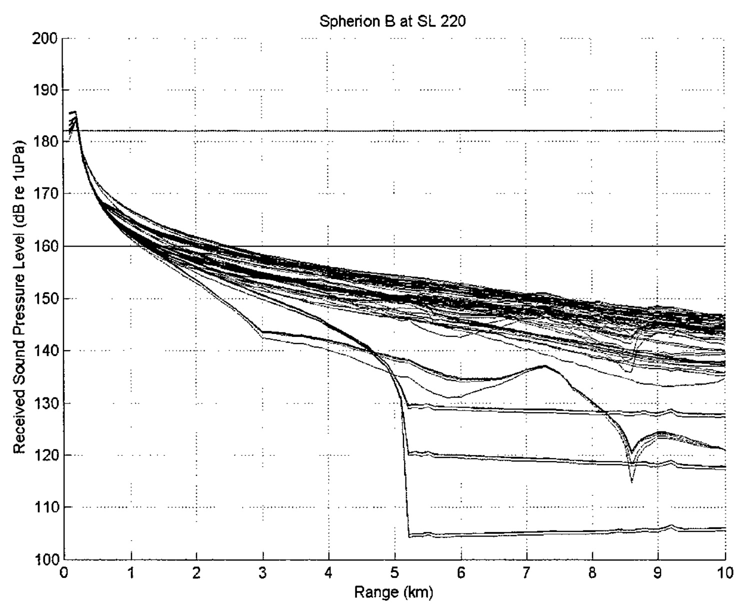

Figure 40: Sound pressure level vs range for the Spherion B source, with the source level changed from 225 dB to 220 dB

A different example would be ASSTASS. This has a lower powered source, so a 5 dB reduction in source level changed the 95% range from 748 m to 436 m at 160 dB (see figures 32 and 41), which is only 312 m compared to Spherion with 2100 m.

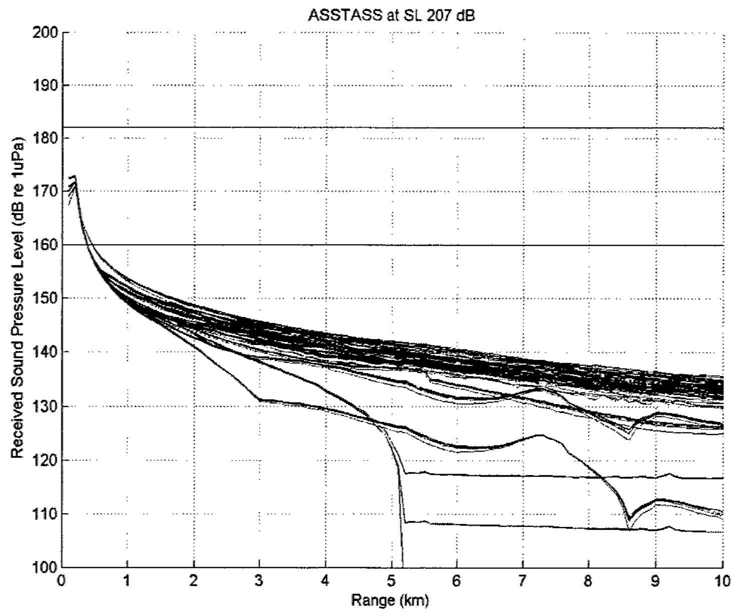

Figure 41: Sound pressure level vs range for the ASSTASS source, with the source level changed from 212 dB to 207 dB

DISTRIBUTION LIST

Environmental Mitigation Ranges Around Australia

Paul Clarke

AUSTRALIA

DEFENCE ORGANISATION

	No. of copies
Task Sponsor	
DGNSPF	1
S&T Program	
Chief Defence Scientist	shared copy
FAS Science Policy	shared copy
AS Science Corporate Management	shared copy
Director General Science Policy Development	shared copy
Counsellor Defence Science, London	Doc Data Sheet
Counsellor Defence Science, Washington	Doc Data Sheet
Scientific Adviser to MRDC, Thailand	Doc Data Sheet
Scientific Adviser Joint	1
Navy Scientific Adviser	1
Scientific Adviser - Army	Doc Data Sheet
Air Force Scientific Adviser	Doc Data Sheet
Scientific Adviser to the DMO M&A	1
Scientific Adviser to the DMO ELL	Doc Data Sheet
Director of Trials	1
Systems Sciences Laboratory	
Chief of Maritime Operations Division	Doc Data Sht & Dist List
Alan Theobald, MOD Sydney, Research Leader	Doc Data Sht & Dist List
Brian Ferguson, MOD Sydney, Head Environmental Assessment	1
Doug Cato, MOD Sydney, Task Manager	1
Paul Clarke, MOD Edinburgh	3
David Liebing, MOD Edinburgh	Doc Data Sht & Dist List
Chris Gillard, MOD Edinburgh	1
Yong Zhang, MOD Edinburgh	1
Jarrad Exelby, MOD Edinburgh	1
Adrian Jones, Program Office Edinburgh	1
Simon Taylor, MOD Edinburgh	1
Richard Ellem, MOD Edinburgh	1
Kim Baddams, MOD Edinburgh	1
John Lewis, MPD Maribyrnong	1
DSTO Library and Archives	
Library Edinburgh	1 & Doc Data Sheet
Australian Archives	1

Capability Systems Division

Director General Maritime Development	1
Director General Aerospace Development	Doc Data Sheet
Director General Information Capability Development	Doc Data Sheet

Office of the Chief Information Officer

Deputy CIO	Doc Data Sheet
Director General Information Policy and Plans	Doc Data Sheet
AS Information Structures and Futures	Doc Data Sheet
AS Information Architecture and Management	Doc Data Sheet
Director General Australian Defence Simulation Office	Doc Data Sheet

Strategy Group

Director General Military Strategy	Doc Data Sheet
Director General Preparedness	Doc Data Sheet

HQAST

SO (Science) (ASJIC)	Doc Data Sheet

Navy

SO (SCIENCE), COMAUSNAVSURFGRP, NSW	Doc Data Sht & Dist List
Director General Navy Capability, Performance and Plans, Navy Headquarters	Doc Data Sheet
Director General Navy Strategic Policy and Futures, Navy Headquarters	Doc Data Sheet

Army

ABCA National Standardisation Officer, Land Warfare Development Sector, Puckapunyal	e-mailed Doc Data Sheet
SO (Science), Deployable Joint Force Headquarters (DJFHQ) (L), Enoggera QLD	Doc Data Sheet
SO (Science) - Land Headquarters (LHQ), Victoria Barracks NSW	Doc Data Sht & Exec Summ

Intelligence Program

DGSTA Defence Intelligence Organisation	1
Manager, Information Centre, Defence Intelligence Organisation	1
Assistant Secretary Corporate, Defence Imagery and Geospatial Organisation	Doc Data Sheet

Defence Materiel Organisation

Head Airborne Surveillance and Control	Doc Data Sheet
Head Aerospace Systems Division	Doc Data Sheet
Head Electronic Systems Division	Doc Data Sheet
Head Maritime Systems Division	Doc Data Sheet
Head Land Systems Division	Doc Data Sheet
Head Industry Division	Doc Data Sheet
Chief Joint Logistics Command	Doc Data Sheet
Management Information Systems Division	Doc Data Sheet
Head Materiel Finance	Doc Data Sheet

Defence Libraries

Library Manager, DLS-Canberra	Doc Data Sheet
Library Manager, DLS - Sydney West	Doc Data Sheet

OTHER ORGANISATIONS

National Library of Australia	1
NASA (Canberra)	1
John Polglaze, Principal Environmental Scientist, URS Australia Level 3, Hyatt Centre, 20 Terrace Road, East Perth WA 6004	6

UNIVERSITIES AND COLLEGES

Australian Defence Force Academy	
Library	1
Head of Aerospace and Mechanical Engineering	1
Hargrave Library, Monash University	Doc Data Sheet
Librarian, Flinders University	1

OUTSIDE AUSTRALIA

INTERNATIONAL DEFENCE INFORMATION CENTRES

US Defense Technical Information Center	2
UK Defence Research Information Centre	2
Canada Defence Scientific Information Service	e-mail link to pdf
NZ Defence Information Centre	1

ABSTRACTING AND INFORMATION ORGANISATIONS

Library, Chemical Abstracts Reference Service	1
Engineering Societies Library, US	1
Materials Information, Cambridge Scientific Abstracts, US	1
Documents Librarian, The Center for Research Libraries, US	1

SPARES	5
Total number of copies:	**49**

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA				
			1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)	
2. TITLE Environmental Mitigation Ranges Around Australia		3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document (U) Title (U) Abstract (U)		
4. AUTHOR(S) Paul Clarke		5. CORPORATE AUTHOR Systems Sciences Laboratory PO Box 1500 Edinburgh South Australia 5111 Australia		
6a. DSTO NUMBER DSTO-GD-0395	6b. AR NUMBER AR-013-045	6c. TYPE OF REPORT General Document	7. DOCUMENT DATE February 2004	
8. FILE NUMBER 9505/25/229	9. TASK NUMBER Nav 02/030	10. TASK SPONSOR DGNSPF	11. NO. OF PAGES 36	12. NO. OF REFERENCES 1
13. URL on the World Wide Web http://www.dsto.defence.gov.au/corporate/reports/DSTO-GD-0395.pdf			14. RELEASE AUTHORITY Chief, Maritime Operations Division	
15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT *Approved for public release* OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111				
16. DELIBERATE ANNOUNCEMENT No Limitations				
17. CITATION IN OTHER DOCUMENTS Yes				
18. DEFTEST DESCRIPTORS Ocean environments, Environmental management, Environmental protection, Sonar, Sound pressure				

19. ABSTRACT

URS Australia is currently writing a document "Environmental Management Plan for Australian Maritime Exercise Areas" for the ADF. To help URS, MOD has modelled the expected sound pressure levels for a number of different environments and sonar frequencies around Australia. This was used to calculate the mitigation range that could be used when operating different sonars in Australian waters.