



Perth, 03 Dec 2024

William Jones
Environmental Approvals Lead
Mid West Ports
Level 3, 3 Ord St
West Perth, WA 6005

Re: Australian Sea Lion in-air noise exposure

Dear William Jones:

On 3rd October, 2024, I received your email asking for assistance from the Centre for Marine Science and Technology (CMST) at Curtin University regarding the calculation of in-air noise exposures of Australian Sea Lions (*Neophoca cinerea*) during the Geraldton Port Maximisation Project.

After clarifying requirements, as well as available measured or modelled sound level metrics, predicted unweighted noise levels were used to estimate weighted 24-hour cumulative Sound Exposure Level (SEL) in order to compare to the 2024 US National Oceanic and Atmospheric Administration (NOAA) criteria¹ for temporary threshold shift (TTS), permanent threshold shift (PTS), and auditory injury (AUD INJ). The Australian Sea Lion falls into the “Other marine carnivores in air” category with the following characteristics:

Table 1: TTS and AUD INJ thresholds for Other marine carnivores in air

Weighting function: OCA				
Generalised hearing range: 90 Hz – 40 kHz				
			Thresholds	
	Metric	Units	TTS onset	AUD INJ
Impulsive/intermittent noise, criteria 1	SPL 0-pk unweighted	dB re 20 µPa	171	177
Impulsive, intermittent noise, criteria 2	SEL 24h cum weighted	dB re 400 µPa ² s	148	163
Non-impulsive noise	SEL 24h cum weighted	dB re 400 µPa ² s	157	177

Three different scenarios were modelled in the report provided by Mid West Ports to CMST. Scenarios 1 and 2 provided estimates of cumulative sound pressure level (L_{eq}) measured in (unweighted) dB re 20 µPa and averaged over 24 hours, while Scenario 3 provided estimates of peak sound pressure levels per piling L_{peak} in (unweighted) dB re 20 µPa. Using the provided L_{eq} values in conjunction with the appropriate OCA weighting

¹ <https://repository.library.noaa.gov/view/noaa/66184>

function, the 24-h weighted SEL in Scenarios 1 and 2 was calculated for comparison to the criteria, with details of the calculations provided as an Appendix to this letter.

Table 2: Calculated values of weighted 24-hour cumulative SEL.

		SEL 24h (dB re 400 $\mu\text{Pa}^2\text{s}$)
Scenario 1	R1	104.5
	R2	110.0
Scenario 2	R1	96.8
	R2	109.3

Interpretation:

NOAA criteria differ for impulsive/intermittent sound and continuous sound. However, Scenarios 1 and 2 contain both impulsive and continuous sound. Therefore, the received levels at the receiver locations R1 and R2 were compared to NOAA criteria for both sound types.

The 24h SEL for both scenarios at both receiver locations ranged from 97 dB to 110 dB re 400 $\mu\text{Pa}^2\text{s}$ and was thus below the NOAA SEL thresholds for TTS and PTS/AUD INJ for either type of noise.

NOAA applies a dual criterion in terms of cumulative SEL and peak sound pressure level (SPL). Whichever is exceeded first (over the longer ranges) needs to be mitigated. The peak SPL criterion requires knowledge of the instantaneous peak sound pressure of the received pile driving waveform. This was not available in the PMaxP report. Instead, peak octave band levels were given, which were likely computed over some time window, and thus expected to be less than the instantaneous peak sound pressure level required for the NOAA criteria. I note, however, that although the levels in Table 2 of the PMaxP report erred on the low side, they were very well below the NOAA peak SPL criterion.

I further note that received levels were only provided up to 8 kHz, which is close to the peak of the otariid sensitivity (i.e., most sensitive frequency). Noise levels above 8 kHz would likely be lower, and hearing impairment sensitivity would rapidly decrease (see Fig. 1), so, I don't expect the received level metrics to be significantly higher if information >8 kHz were available and added.

Sincerely,



Christine Erbe

Director, Centre for Marine Science & Technology
John Curtin Distinguished Professor, School of Earth & Planetary Sciences

APPENDIX

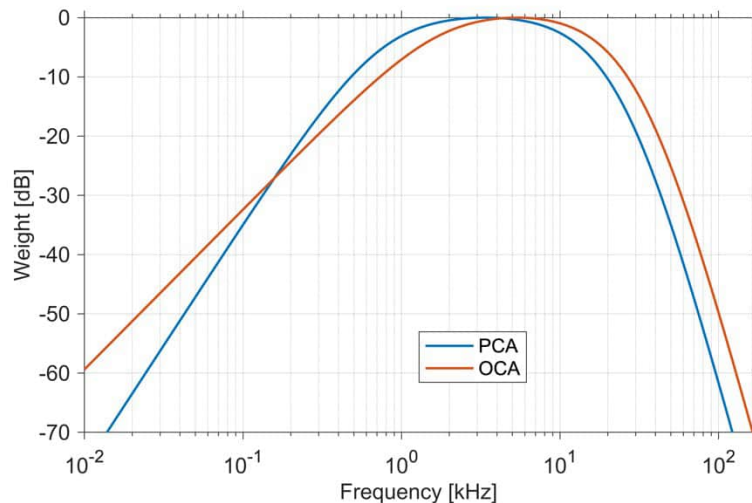


Fig. A.1: NOAA weighting applied to received noise spectra for phocids and otariids in air (PCA, OCA). The red line (OCA) applies to the Australian Sea Lion hearing in air.

Table A.1: NOAA M-weighting

Centre frequency [Hz]	16	31.5	63	125	250	500	1000	2000	4000	8000
M-weight OCA [dB]	-53.87	-45.93	-37.81	-29.8	-21.76	-13.98	-7.06	-2.24	-0.17	-0.37

Table A.2: Predicted unweighted noise levels in dB(lin). Cumulative sound pressure level L_{eq} in dB(lin) averaged over 24 hours for scenarios 1 and 2. Peak sound pressure level L_{peak} in dB(lin) per piling. Reproduced from PMaxP report.

Receivers	Octave Band Sound Power Levels in dB(lin)										Overall dB(lin)
	16	31.5	63	125	250	500	1000	2000	4000	8000	
Leq for Scenario 1											
R1	46.4	61.4	62.1	59.9	58.7	56.7	53.5	47.9	37.2		67.4
R2	53.9	65.4	65.4	65.7	64.1	61.2	59.6	52.8	45.8		72
Leq for Scenario 2											
R1	37	54.8	52	51.9	50.4	50.5	45.3	38.5	30.1		59.5
R2	50.9	66.5	63.8	62.7	60	59	58.9	54.4	46.2		70.7
Lpeak for Scenario 3											
R1	85.4	87.6	96.3	97.3	103.5	102.1	106.3	113.8	97.4	85.3	115.3
R2	79.5	81.9	90.9	92.5	98.2	96.7	99	104.4	86	64.8	107



Table A.3: Calculation of weighted 24h cumulative Sound Exposure Level (SEL) [dB re 400 $\mu\text{Pa}^2 \text{s}$]

	16	31.5	63	125	250	500	1000	2000	4000	8000		
	L_{eq} for Scenario 1										SEL aver.	SEL 24h
R1	0.47	23.59	32.3	38.14	44.72	49.64	51.26	47.73	36.83		55.16	104.52
R2	7.97	27.59	35.6	43.94	50.12	54.14	57.36	52.63	45.43		60.62	109.99
	L_{eq} for Scenario 2											
R1	-8.93	16.99	22.2	30.14	36.42	43.44	43.06	38.33	29.73		47.46	96.82
R2	4.97	28.69	34	40.94	46.02	51.94	56.66	54.23	45.83		59.91	109.27