BEFORE THE WHANGAREI DISTRICT COUNCIL AND NORTHLAND REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of a resource consent application by Northport Limited under section 88 of the Resource Management 1991 for a port expansion project at Marsden Point
APPLICATION NO.	APP.005055.38.01 LU 2200107

STATEMENT OF EVIDENCE OF MATTHEW PINE

(UNDERWATER NOISE)

24 August 2023

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INTRODUCTION

1. My full name is Matthew Keith Pine. I am a marine scientist specialising in underwater noise and ocean bioacoustics. I am a Principal Consultant at Styles Group Underwater Acoustics.

Qualifications and experience

2. I hold a Ph.D. in Marine Science from the University of Auckland. I have completed two post-doctoral research fellowships at the Institute of Hydrobiology, Chinese Academy of Sciences in China (2 years) and the Department of Biology at the University of Victoria in British Columbia, Canada (3 years). My scientific research in these roles focused on the impact of underwater anthropogenic noise on marine mammals and fish.

3. I have published over 40 articles in international, peer-reviewed scientific journals on the effects of noise on marine fauna.

4. I have extensive experience in the acoustic monitoring of marine mammals and modelling of anthropogenic noise sources in the coastal marine area. I have been involved in a significant number of projects in New Zealand and internationally involving marine mammal monitoring, soundscape characterisation, sound source verification, passive acoustic surveys, marine mammal detection, and advanced underwater noise modelling.

5. I also have extensive experience in computer programming and have created a range of analytical software used by marine mammal researchers in conservation organisations and government organisations (such as Parks Canada).

6. I have worked on numerous projects around New Zealand involving the management of underwater noise effects from activities in the coastal marine area, including pile driving, dredging, blasting and sand extraction.

Code of Conduct

7. I confirm that I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note (2023) and I have complied with it when preparing this evidence. Other than when I state that I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

INVOLVEMENT

8. Styles Group was engaged by Northport in July 2020 to assess the noise effects arising from the proposed port expansion project. I prepared the *Assessment of Underwater Noise Effects* (2 August 2022) and consulting advice note on noise effects on little penguin/kororā (16 June 2023) (together, the Underwater Noise Assessments).

9. The purpose and scope of the Underwater Noise Assessments is to:
    i. Model the underwater piling and dredging noise associated with the proposed reclamation.
    ii. Assess the potential extent of hearing threshold shifts (both permanent and temporary), behavioural responses and auditory masking in marine mammals.
    iii. Assess the potential extent of hearing threshold shifts and injury in fishes.

10. The Underwater Noise Assessments have been used to inform the assessment of effects on marine mammals, fish and penguins prepared by the respective ecologists from Cawthron, Coast & Catchment Ltd and Boffa Miskell.

11. The assessment of the actual or potential effects on marine mammals, fish and penguins are contained entirely within the respective ecological reports from Cawthron, Coast & Catchment Ltd and Boffa Miskell and should be referred to for a full understanding of the effects on, and recommendations for protecting marine species.

SCOPE OF EVIDENCE

12. My evidence includes the following:
    i. A summary of the matters covered in my Underwater Noise Assessments.
    ii. Conclusions on the underwater noise effects and ranges within which those effects can be expected.
    iii. Comment on the s42A report.
    iv. Response to submissions received.

v. Comment on the draft proposed conditions proposed by Northport.

13. In preparing this evidence I have reviewed:

i. The assessment of marine ecological effects from Coast & Catchment Ltd (Kelly & Sim-Smith, 2022).

ii. The assessment of potential effects on marine mammals from the Cawthron Institute (Clement 2022).

iii. The coastal avifauna assessment from Boffa Miskell (Bull 2022).

CRITERIA FOR UNDERWATER NOISE

14. There is no specific guidance on underwater noise effects criteria in New Zealand. I have therefore adopted overseas standards and peer-reviewed research as is commonly done in New Zealand and internationally.

15. The marine mammal acoustic technical guidance (published in 2018) from the National Marine Fisheries Services (NMFS) of the U.S. Department of Commerce is used extensively for underwater noise assessments in New Zealand and internationally. I have therefore relied on that guidance for marine mammal species, alongside recent peer-reviewed research.

16. For effects on fish species, the 2014 American National Standard Institute (ASNI) accredited sound exposure guidelines for fishes and sea turtles was used (Popper et al. 2014).

17. For penguins, no technical guidance on the effects of noise currently exists and I therefore relied on peer-reviewed scientific research.

SPECIES OF INTEREST

18. Dr Clement's evidence identifies twelve species of marine mammals that may be present within Whangarei Harbour. These species are summarised in Table 1:

Table 1: Species of interest in and around Whangarei Harbour specifically considered in the underwater noise assessment.			
Common Name	**Species Name**	**NZ Threat Classification**	**Function Hearing Group in NMFS (2018)**
Bottlenose dolphin	*Tursiops truncates*	Nationally endangered	Mid-frequency cetacean (MF)
Common dolphin	*Delphinus delphis*	Not threatened	Mid-frequency cetacean (MF)
Killer whale	*Orcinus orca*	Nationally critical	Mid-frequency cetacean (MF)
Bryde's whale	*Balaenoptera brydei*	Nationally critical	Low-frequency cetacean (LF)
Southern right whale	*Eubalaena australis*	At risk – recovering	Low-frequency cetacean (LF)
Humpback whale	*Megaptera novaeangliae*	Migrant	Low-frequency cetacean (LF)
Pilot whale	*Globicephala melas*	Not threatened	Mid-frequency cetacean (MF)
Sperm whale	*Physeter marcocephalus*	Data deficient	Mid-frequency cetacean (MF)
False killer whale	*Pseudorca crassidens*	At risk	Mid-frequency cetacean (MF)
Blue whale	*Balaenoptera muculus*	Data deficient	Low-frequency cetacean (LF)
New Zealand fur seal	*Arctocephalus forsteri*	Not threatened	Otariid pinnipeds (OW)
Leopard seal	*Hydrurga leptonyx*	At risk	Phocid pinnipeds (PW)

19. All the marine mammal species in Table 1 are represented by four functional hearing groups: low-frequency (LF), mid-frequency (MF), Otariid pinnipeds (OW) or Phocid pinnipeds (PW), based on the 2018 NMFS technical guidance.

20. A specific assessment of the most reported marine mammal species in and around Whangarei Harbour was undertaken. These species are bottlenose dolphins, common dolphins, killer whales, pilot whales, baleen whales (humpback, Bryde's, southern right and blue whales), NZ fur seal and leopard seals (the "specific species")

21. The specific species have similar hearing sensitivities to the other species listed in Table 1. From a bioacoustics perspective, the specific species are an appropriate proxy for all other marine mammal species identified as possible receivers in the area.

22. Fish species are highly diverse in the area and my assessment considered all species generally rather than any specific species. This approach follows the above-stated technical guidance for fishes.

23. A specific assessment was also undertaken for little penguins/kororā.

ASSESSMENT METHODOLOGY

24. My assessment focused on the potential noise effects from the loudest noise sources associated with the application. Specifically:

    i. The percussive piling of the top-driven piles (H-section, sheet or solid steel piles with diameters between 25mm and 760mm).

    ii. The operation of the "City of Chichester" trailing suction hopper dredger (TSHD) vessel. The TSHD is 72m in length with a 1418m^3 capacity, 2720 kW power, full dredging sand/gravel).

    iii. The operation of the "Florida" cutter-suction dredger (CSD),18938 kW total installed power, full cutter dredging.

    iv. The operation of the "New York" backhoe dredger (BHD), 18m^3 capacity, 2565 kW total power, bucket impact and removing sand/gravel.

25. Noise effects from the vibratory piling are not expected to be greater than the percussive piling, due to lower noise emissions and higher effects thresholds than for percussive piling.

26. The potential noise effects specifically assessed were:

a. Injury (permanent threshold shift, PTS).[1]

b. Temporary hearing loss (Temporary threshold shift, TTS).[2]

c. Behavioural effects.

d. Auditory masking.[3]

27. Generally, noise effects can only occur if the invading noise source is audible, with audibility being a function of both the ambient sound level and hearing thresholds of the listener.

28. Therefore, to properly assess the maximum spatial extent of possible acoustic disturbance, the ambient soundscape must be fully considered and incorporated into the effects modelling (in the context of the species' hearing thresholds and critical bandwidths).

29. To assess the potential underwater noise effects of the pile driving and capital dredging, data were obtained to investigate the existing soundscape of the area. This involved the deployment of autonomous underwater sound recorders (SoundTrap 300HF recorders, Ocean Instruments NZ) at four locations around the harbour entrance, as identified in Figure 1 below:

[1] Permanent threshold shifts (PTS) refer to injury where hearing sensitivities do not return to normal following noise exposure.
[2] Temporary threshold shifts (TTS) refer to injury where heading sensitivities do return to pre-exposure thresholds after a period of time following noise exposure.
[3] Auditory masking is the interference of a biologically important signal (such as vocalisations from a predator/prey etc) by an unimportant noise that prevents the listener from properly perceiving the signal.

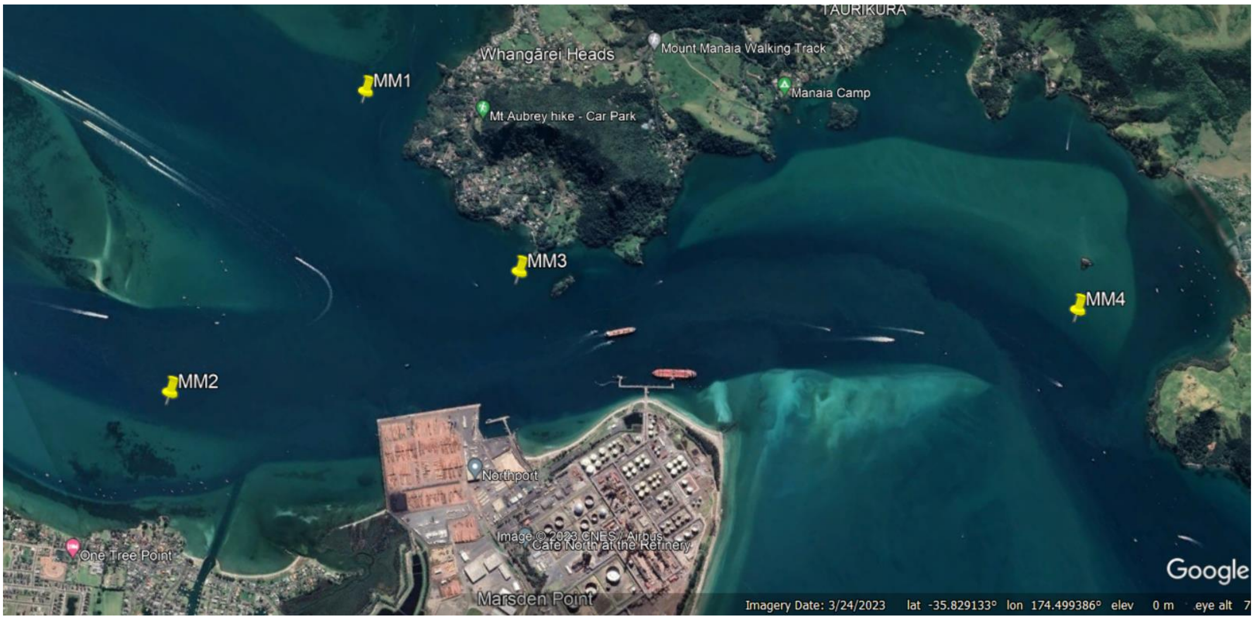

Figure 1: Map showing approximate locations of each SoundTrap recorder

30. Analyses confirmed that the underwater noise levels (wideband, i.e., 10Hz – 96kHz) at and around Northport were relatively high, primarily due to vessel and port activities. For example, at the MM3 site, hourly sound pressure levels (SPL) between July and August 2020 ranged from 108 dB_{rms} re 1 µPa to 146 dB_{rms} re 1 µPa (average 125 dB_{rms} re 1 µPa) as ships entered and left Northport.

31. Continuous engine and generator noise from berthed ships (approximately 700-1000m from the MM3 site) was a considerable source of anthropogenic noise in the existing soundscape, particularly below 1kHz. Previous studies have also shown this effect from berthed or anchored vessels on the surrounding soundscape (Murchy et al. 2022).

32. Small boat noise was also common, especially in the summer months with recreational vessels frequently operating in the area. Recreational vessels in busy areas can increase ambient sound levels by several decibels. A recent study found that 10% increase in daily vessel activity can lead to 2 dB increases in background ocean noise (Pine et al. 2021).

33. The Underwater Noise Assessments should be referred to for a full description of the data collection methodology and analysis procedure.

34. Effects ranges for each species, in the context of the existing sound environment, are provided in the tables contained in Appendix A and are summarised below.

MARINE MAMMALS

35. The predicted noise emissions from piling and capital dredging were evaluated in terms of the critical distances for which risk of injury (PTS), changes to hearing abilities (TTS), behavioural effects (as a percentage of risk over range), and auditory masking will occur for the marine mammal species of interest.

Percussive Piling

Injury (PTS and TTS)

36. A risk of PTS and TTS for marine mammals exists within a limited range from a percussive piling source. This finding is based on the source levels of the percussive piling and subsequent exposure levels being above the 2018 NMFS thresholds or PTS and TTS.

37. A risk of PTS can be expected within 26m for dolphin species, 145m for leopard seals and 475m for large whales during the percussive piling. No risk of PTS is expected in NZ fur seals.

38. A risk of TTS can be expected within 183m for dolphin species, 765m for leopard seals, 1348m for large whales and 111m for NZ fur seals.

Behavioural effects

39. The Underwater Noise Assessment dated 2 August 2022 should be referred to for a full description of the methods used to assess behavioural effects in marine mammals.

40. Behavioural effects from percussive pile driving for all marine mammal species listed in Table 1 were assessed using step function thresholds of 140 and 160 dB_{rms} re 1 µPa (unweighted). Published reviews show most marine mammals responding to impulsive noise of varying levels between 140 and 180 dB_{rms} re 1 µPa, including large whales (Malme et al. 1983, 1984; HESS 1999; Woods et al. 2012). The step function threshold of 160 dB_{rms} re 1 µPa also reflects the NMFS threshold for the potential onset of behavioural effects from marine mammals.

41. It was therefore considered that at or above 140 dB_{rms} re 1 µPa, there was some potential for behavioural effects for marine mammals occurring (i.e., >10% (Woods et al. 2012)). At or above 160 dB_{rms} re 1 µPa, that potential increases and behavioural effects are far more likely to be observed (>50%).

42. That 140 dB_{rms} re 1 µPa threshold for some behavioural effect occurring (i.e., >10% chance) will be exceeded at 2047m from the percussive piling source. Within 969m, the 160 dB_{rms} re 1 µPa threshold is exceeded, and therefore, >50% chance of behaivoural effects occurring.

Auditory masking

43. Auditory masking effects on the species of interest were assessed by quantifying the reduction in a species 'listening space'- the immediate area or volume of ocean within which a species can detect and perceive a biologically important signal. The Listening Space Reduction (LSR) is a measure of how much smaller the listening space of an animal becomes with the noise of interest present in the environment. In other words, when the noise of interest is not present, the animal will be able to hear sounds from a certain distance away. When the noise of interest is present, the same sounds will only be audible and perceivable if the distance between the animal and the sound source is smaller.

44. In human terms, the LSR can be understood by considering the ability for a person to hear and understand another person talking at normal speech volumes, but in different environments. In a very calm and desolate environment (e.g., a cold landscape) a person may be able to hear and understand another person talking at a distance of (say) 10m. However, the same person talking at the same volume in an inner-city environment may not be able to be heard and understood until they are within (say) 5m of the person listening. This would be a 50% reduction in listening space (i.e., an LSR of 50%). The noise from the inner-city activity has masked the sound of the person talking.

45. The LSR for percussive piling was highest for leopard seals (LSR of 50% within 1397m), followed by fur seals (50% LSR within 1334m), bottlenose/common dolphins (50% LSR within 1295m), killer whales (50% LSR within 1279m) then mysticete whales (such as humpback whales (50% LSR within 1065m)). The spatial extent of any auditory masking (i.e., greater than 1% LSR) was highest for leopard seals (2914m), followed by fur seals (2841m), mysticete whales (2851m), killer whales (2828m) then bottlenose/common dolphins (2782m).

Trailing-suction hopper dredger (TSHD)

Injury (PTS and TTS)

46. Injury (PTS and TTS) from the TSHD noise is not expected to occur beyond 1m, at any stage of operation (including active dredging) within the area, for any species. These findings are based on the source levels and subsequent exposure levels being below the 2018 NMFS thresholds for PTS and TTS.

Behavioural effects

47. Behavioural effects were assessed in the context of low or moderate behavioural responses. Examples of low severity behavioural responses include alert behaviours, minor changes to swimming speeds, dive profiles or directions, changes to respiratory rates or minor cessation or modification of vocalisations (Joy et al. 2019). Examples of moderate severity behavioural responses include prolonged changes to swimming speeds, dive profiles, or directions, moderate shifts in distributions, prolonged cessation or modification of vocalisations.

48. There is a 50% chance for low severity behavioural responses occurring within 1055m for large whales (such as Bryde's and humpback whales), and 451m for dolphin species. The probability of low severity responses increases to over 75% within 884m for whales and 327m for dolphin species.

49. For dolphin species, there is a 50% chance for moderate severity behavioural responses occurring within 245m and within 171m that probability increases to above 75%.

50. For pinniped species, the potential onset for low severity responses occurs within 1033m, while moderate severity responses can be expected within 461m from the TSHD while actively dredging.

Auditory masking

51. Similar to percussive piling, auditory masking effects for marine mammals can be expected within a limited distance from the TSHD while actively dredging.

52. The LSR was highest for leopard seals (LSR of 50% within 420m), followed by fur seals (50% LSR within 395m), killer whales (50% LSR within 333m), bottlenose and common dolphins (50% LSR within 308m), then mysticete whales (such as humpback whales (50% LSR within 259m)). The spatial extent of any auditory

masking (i.e., greater than 1% LSR) was highest for leopard seals (1190m), followed by fur seals (1102m), mysticete whales (1081m), killer whales (1055m) then bottlenose/common dolphins (1027m).

Cutter-suction dredger (CSD)

Injury (PTS and TTS)

53. Injury (PTS and TTS) is not expected to occur beyond 1m of the CSD at any stage of operation (including active dredging) within the area, for any species. These findings are based on the source levels and subsequent exposure levels being below the 2018 NMFS thresholds for PTS and TTS.

Behavioural effects

54. There is a 50% chance for low severity behavioural responses occurring within approximately 503m for large whales (such as Bryde's and humpback whales), and 202m for dolphin species. The probability of low severity responses increases to over 75% within 425m for whales and 168m for dolphin species.

55. For dolphin species, there is a 50% chance for moderate severity behavioural responses occurring within 90m and within 58m that probability increases to above 75%.

56. For pinniped species, the potential onset for low severity responses occurs within 505m, while moderate severity responses can be expected within 197m of the CSD actively dredging.

Auditory masking

57. The LSR was highest for leopard seals (LSR of 50% within 101m), followed by fur seals (50% LSR within 70m), bottlenose and common dolphins (50% LSR within 41m), killer whales (50% LSR within 34m), then mysticete whales (such as humpback whales (50% LSR within 24m)). The spatial extent of any auditory masking (i.e., greater than 1% LSR) was highest for leopard seals (578m), followed by fur seals (434m), mysticete whales (415m), killer whales (403m) then bottlenose/common dolphins (398m).

Backhoe dredger (BHD)

Injury (PTS and TTS)

58. Injury (PTS and TTS) is not expected to occur beyond 1m of the BHD at any stage of operation (including active dredging) within the area, for any species. These findings are based on the source levels and subsequent exposure levels being below the 2018 NMFS thresholds for PTS and TTS.

Behavioural effects

59. There is a 50% chance of low severity behavioural responses occurring within approximately 468m for large whales (such as Bryde's and humpback whales), and 185m for dolphin species. The probability of low severity responses increases to over 75% within 398m for whales and 178m for dolphin species.

60. For dolphin species, there is a 50% chance for moderate severity behavioural responses occurring within 93m and within 57m that probability increases to above 75%.

61. For pinniped species, the potential onset for low severity responses occurs within 377m, while moderate severity responses can be expected within 202m of the BHD actively dredging.

Auditory masking

62. Auditory masking for the quieter BHD was substantially less than the other dredging vessels (50% LSRs are not expected). The LSR was highest for leopard seals (LSR of 25% within 236m), followed by fur seals (25% LSR within 172m), mysticete whales (such as humpback whales (25% LSR within 161m)), bottlenose and common dolphins (25% LSR within 148m), then killer whales (25% LSR within 146m). The spatial extent of any auditory masking (i.e., greater than 1% LSR) was highest for leopard seals (591m), followed by fur seals (343m), mysticete whales (334m), bottlenose/common dolphins (308m), then killer whales (304m).

FISHES

63. Fish and invertebrates can be negatively impacted by anthropogenic noise, just as marine mammals. Data that establishes the expected severity of a certain effect following exposure to some pressure levels are scare and even more so for particle

motion levels. The only peer-reviewed guidance for the potential onset of noise effects (from a range of sources, including piling) on fishes that has experienced some uptake internationally is the ANSI-accredited guidance from Popper et al. (2014). For percussive pile-driving, the criteria for various fish-groups are provided as decibel ranges. No guidance on vessel or dredging noise exists and have therefore fallen outside the scope for a specific analysis.

64. While thresholds are a good starting point, noise criteria for fishes should consider the biological significance of sound exposure (Hawkins et al. 2020). The biological significance of the sound exposure relates to whether the animal experiences an adverse effect from the noise that is likely to cause significant physical, chemical or biological responses that have real consequences for the net fitness of the individual or population (Hawkins et al. 2020).

65. The only effect that can currently be directly linked to such an impact is mortality or severe injury that eventually may be fatal. Other biologically significant effects include PTS, TTS, sub-lethal injuries, behavioural and auditory masking but the relationship between the severity of those effects and exposure to noise is data deficient and still a research question (Hawkins et al. 2020).

66. Notwithstanding, hearing loss (either permanent or temporary) is an impact that can impact an individual's net fitness because their perception of predators can be inhibited. I therefore considered the risk of TTS and injury in fishes from percussive piling.

Injury and TTS

67. Injury and TTS effects from percussive pile-driving are possible within a limited range. I have assumed minimal movement of fishes when exposed to piling noise to maintain conservativeness.

68. For fishes with swim bladders, there is a risk of recoverable injuries within 78m of the percussive piling.

69. Fishes without swim bladders could be exposed to a risk of recoverable injuries within 40m of the percussive piling.

70. In all fishes, it can be expected that the onset of potential TTS effects could happen within 317m of the percussive piling.

KORORĀ/LITTLE PENGUINS

71. No noise guidance on underwater noise effects on seabirds exists at all and research data on the negative effects are very scarce. However, anthropogenic noise is audible to penguins and behavioural effects have been reported in peer-reviewed scientific literature. Some penguins are also known to vocalise underwater (Thiebault et al. 2019).

72. Two recent studies (Pichegru et al. 2017 and Sørensen et al. 2020) have shown behavioural responses in penguins (respectively the African penguin and Gentoo penguin) when exposed to anthropogenic noise. Those sources were airguns during a commercial seismic survey approximately 100km away (Pichegru et al. 2017) and artificial sounds played back in a tank (Sørensen et al. 2020).

73. Those studies demonstrated that penguins are able to detect and perceive sound underwater and that they can respond to it. Unfortunately, however, we are unable to robustly relate those published data to this application because:

    (a) behavioural effects are highly contextual; and

    (b) applying simplistic noise thresholds for behavioural effects based on very little data, at the individual or population level, is generally avoided (Faulkner et al. 2018), and thresholds are not proposed at all when no data are available (for example, see Tougaard 2021).

74. Consequently, TTS and behavioural effects were unable to be specifically assessed.

75. To inform an effects assessment for kororā, conservative masking and audibility ranges from the pile-driving and dredging were calculated. The methods used for those calculations reflected those used for marine mammals, but for all decidecade bands, the audiogram value equalled the ambient noise level.

76. Masking release mechanisms, detection thresholds, auditory gain functions and directionality of hearing sensitivities were all excluded from the masking and audibility limit calculations in the interest of conservativeness. True masking will therefore lie within the ranges in my assessment.

Auditory Masking

Auditory masking effects are expected to occur over the furthest ranges from the percussive piling (≥50% LSR within 1671m), followed by dredging using a TSHD

(≥50% LSR within 678m), the CSD (≥50% LSR within 199m) and BHD (≥50% LSR within 122m).

CUMULATIVE NOISE EFFECTS

77. There is a possibility that percussive pile-driving and dredging could occur at the same time.

78. An assessment of cumulative noise effects was undertaken by modelling the dredging and percussive piling activities at the shortest possible distance that they may occur from each other (approximately 400m).

79. The cumulative noise levels were assessed by determining the noise levels at a single receiver point, located approximately equidistant between the two activities.

80. The modelling results showed no cumulative noise effects from the dredging occurring at the same time as the percussive piling. This can be explained by the ranges and propagation pathways between the two sources and the substantial differences in the noise sources themselves (dynamics and amplitude).

SECTION 42A STAFF REPORT

81. I have reviewed the relevant sections of the Section 42A Report relating to underwater noise and adverse ecological effects. I have also reviewed the peer-review report prepared by Dr Jonathan Vallarta from SLR Consulting in Canada.

82. Dr Vallarta concurs with the findings of my underwater noise assessment and agrees with the methodology used, and that my assessment provides an appropriate baseline for the other independent experts engaged by Northport.

83. Dr Vallarta further concurs that the MMMP is an acceptable mitigation measure for the proposed percussive piling.

84. The Section 42A Report authors agree with the underwater noise assessment. They conclude the approach to, and proposed mitigation of, underwater noise satisfies Policy D.5.27.

RESPONSE TO SUBMISSIONS RECEIVED

85. No submissions were received that raised issues directly relevant to the Underwater Noise Assessments requiring comment.

COMMENT ON DRAFT PROPOSED CONDITIONS ADVANCED BY NORTHPORT

86. I have reviewed the draft proposed conditions being advanced by Northport. Insofar as they relate to the Underwater Noise Assessments - including the proposed Marine Mammal Management Plan (MMMP), verification of in-situ noise levels produced by pile-driving activities, and measures to reduce underwater noise - I consider them to be generally appropriate.

Matthew Pine

Styles Group Underwater Acoustics
24 August 2023

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APPENDIX A: NOISE EFFECTS TABLES

MARINE MAMMALS

Percussive Piling

Injury (PTS and TTS)

Table 1: Ranges for the potential onset of permanent threshold shift (PTS) for the four functional hearing groups of marine mammals.

Species	Critical Range (m)
Bryde's whales, southern right whales, humpback whales, blue whales (LF)	475
Killer whales, false killer whales, pilot whales, sperm whales, bottlenose dolphins, common dolphins (MF)	26
Leopard seals (PW)	145
NZ Fur seals (OW)	0

Table 2: Ranges for the potential onset of temporary threshold shift (TTS) for the four functional hearing groups of cetaceans.

Species	Critical Range (m)
Bryde's whales, southern right whales, humpback whales, blue whales (LF)	1348
Killer whales, false killer whales, pilot whales, sperm whales, bottlenose dolphins, common dolphins (MF)	183
Leopard Seals (PW)	765
Fur Seals (OW)	111

Behavioural effects

Table 3: Distances at which the potential onset of behavioural responses may occur from the percussive piling.

Species	Threshold	
	140dB	**160dB**
All Species	2047m	969m

Trailing-suction hopper dredger (TSHD)

Behavioural effects

Table 4: Distances at which 75, 50, 25 and 0% risk of low and moderate behavioural responses for each of the species of interest may occur.

Species	Behavioural Response	Risk isopeth (m)			
		75%	**50%**	**25%**	**0%**
Killer whale	Low*	327	451	544	935
Bottlenose dolphin **Common dolphin** **Pilot whale** **False killer whale**	Moderate**	171	245	324	585
Whales (excl. killer whales and sperm whales.	Low	884	1055	1202	1635
Fur Seal	Low	Potential Onset: 1033m			
Leopard Seal	Moderate	Potential Onset: 461m			

*Minor changes in respiration rates, swimming speeds/direction.

**Moderate to extensive changes in swimming speeds/direction and/or diving behaviours, moderate or prolonged cessation of vocalisations, and/or avoidance.

Cutter-suction dredger (CSD)

Behavioural effects

Table 5: Distances at which 75, 50, 25 and 0% risk of low and moderate behavioural responses for each of the species of interest may occur.

Species	Behavioural Response	Risk isopeth (m)			
		75%	50%	25%	0%
Killer whale Bottlenose dolphin Common dolphin Pilot whale False killer whale	Low*	168	202	290	422
	Moderate**	58	90	138	293
Whales	Low	425	503	577	621
Fur Seal Leopard Seal	Low	Potential Onset: 505m			
	Moderate	Potential Onset: 197m			

*Minor changes in respiration rates, swimming speeds/direction.
**Moderate to extensive changes in swimming speeds/direction and/or diving behaviours, moderate or prolonged cessation of vocalisations, and/or avoidance.

Backhoe dredger (BHD)

Behavioural effects

Table 6: Distances at which 75, 50, 25 and 0% risk of low and moderate behavioural responses for each of the species of interest may occur.

Species	Behavioural Response	Risk isopeth (m)			
		75%	50%	25%	0%
Killer whale Bottlenose dolphin Common dolphin Pilot whale False killer whale	Low*	178	185	263	368
	Moderate**	57	93	135	259

Table 6: Distances at which 75, 50, 25 and 0% risk of low and moderate behavioural responses for each of the species of interest may occur.

Whales	Low	398	468	514	608
Fur Seal	Low	Potential Onset: 377 m			
Leopard Seal	Moderate	Potential Onset: 202 m			

*Minor changes in respiration rates, swimming speeds/direction.

**Moderate to extensive changes in swimming speeds/direction and/or diving behaviours, moderate or prolonged cessation of vocalisations, and/or avoidance.

FISHES

Percussive Piling

Injury (PTS and TTS)

Table 7: Ranges for the potential onset of noise impacts from the percussive piling in fishes, based on the ANSI-Accredited guideline thresholds (Popper et al. 2014)

Fishes	Critical Range (m)
Injury (including recoverable and fatal) in fishes without swim bladders (particle motion detection)*	40
Injury (including recoverable and fatal) in fishes with swim bladders (particle motion and pressure detection)*	78
TTS (All fishes)**	317

* *Lpk* thresholds for fatal and recoverable injuries are the same and therefore grouped together in this assessment.

** The *SELcum* thresholds are the same for all fish-groups and therefore grouped together in this assessment.

KORORĀ/LITTLE PENGUINS

Auditory Masking

Table 8: Distances at which 75%, 50%, 25% and 0% listening space reduction (LSR) occurs in little penguin/kororā for the percussive piling and capital dredging

Activity	Critical Distance (m)			
	75% LSR	**50% LSR**	**25% LSR**	**0%LSR**
Percussive piling	899m	1671m	2808m	3811m
Trail-suction hopper dredger	456m	678m	1267m	2326m
Cutter-suction dredger	92m	199m	419m	675m
Backhoe dredger	N/A	122m	340m	752m

Note: N/A stands for Not Applicable