BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY
AT WELLINGTON

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
AND	
IN THE MATTER	of a decision-making committee appointed to hear a marine consent application by Trans Tasman Resources Limited to undertake iron ore extraction and processing operations offshore in the South Taranaki Bight

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EXPERT EVIDENCE OF DR SIMON JOHN CHILDERHOUSE ON BEHALF OF TRANS TASMAN RESOURCES LIMITED

15 DECEMBER 2016

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EXECUTIVE SUMMARY

1. There is a low likelihood of marine mammals being present in the proposed Trans Tasman Resources Limited (TTRL) mining area and there is nothing to suggest that the mining area is of any significance to any marine mammal species. These conclusions are supported by dedicated marine mammal surveys of the proposed mining area and by existing knowledge about how marine mammals use the greater Taranaki area. While Māui dolphins and/or Hector's dolphins are found in very low numbers in the STB region, the operational area is at the margins of the southern-most recognised range for Māui dolphins. It appears very unlikely that Māui dolphins are present in the TTRL operational area given that the majority of their distribution is considerably further north of this site.

2. Dredges produce noise across a broad range of frequencies which overlaps with the hearing range of some marine mammal groups. In general, the dominant frequency ranges from dredges is lower than the sensitivity range for most marine mammal groups, with the exception of some baleen whales. Therefore, impacts from noise are likely to be considerably less for high and mid-frequency cetaceans (e.g. dolphins) as the noise will be less audible to them.

3. If noise levels of the dredge are comparable to those of shipping as the literature suggests, then behavioural, rather than physiological effects (e.g. Temporary (TTS) or Permanent Threshold Shift (PTS) in hearing) are likely to be of more concern. Overall, while the risk of behavioural disturbance is low to moderate, this effect will only be evident in the area immediately around the operation. While TTS and PTS are theoretically possible, they are highly unlikely given the length of time and close approach a marine

mammal would need to make to potentially be effected and therefore represents a negligible risk.

4. While there exists the potential for behavioural modification (e.g. exclusion from the area), given that the area over which the noise will be audible is likely to be relatively small (e.g. an area potentially a maximum of several km around the source) the effect on individuals, let alone species in the STB, is likely to be extremely limited. Furthermore, any marine mammals that may be in the vicinity of the dredge and are disturbed by noise, could move away at a rate much faster than that of the factory and crawler (i.e. 70 metre per hour).

5. Overall, in my opinion, the proposed conditions and associated documentation described in the application provide a comprehensive set of monitoring, mitigation and management that will: (i) minimise any impact on marine mammals from the activity; and (ii) provide adequate monitoring so that any potential impact that may occur is detected. I believe the proposed conditions are appropriate to the low level of risk posed by the mining activity for marine mammals. Furthermore, I understand that the Department of Conservation (DOC) has had input into the development of the conditions relating to marine mammals and that DOC is satisfied with them in their present form.

INTRODUCTION

Qualifications and experience

1. My name is Dr Simon John Childerhouse. I am a Marine Scientist specialising in marine mammals.

2. I have a PhD in Marine Science (2009; Thesis – Conservation Biology of New Zealand sea lions) and a Post Graduate Diploma in Wildlife Management (1993; Thesis – Individual photographic identification and population size estimates for sperm whales at Kaikoura, New Zealand) from the University of Otago and a BSc in Zoology (1991) from the University of Auckland.

3. I have worked as a marine mammal scientist for more than 20 years in New Zealand, Australia, Antarctica, USA, Canada and the South Pacific. My work has included pure and applied marine research, leading and project managing large scale, international research projects, publication across a broad range of marine research, lecturing and teaching at various universities, representation of both Australian and New Zealand Governments at international meetings, development of national and international policy and strategic documents, and delivering applied and practical solutions to challenging marine conservation and resource-utilisation issues. I have considerable experience in the ecology and behaviour of marine mammals and the identification and mitigation of impacts of anthropogenic activities, including noise, on marine mammals.

4. I am familiar with the impacts and consequences of noise on marine mammals, and how the effects of noise can be mitigated. My specific experience relating to noise and marine mammal issues includes:

(a) The assessment and mitigation of the impacts of seismic surveys on marine mammals for the Australian Government;

(b) Development of DOC - approved Marine Mammal Impact Assessments and Marine Mammal Mitigation Plans for seismic surveys in New Zealand; and

(c) Involvement with the development of noise monitoring and mitigation plans for marine activities including multibeam surveys, pile driving and dredging.

5. I appeared as an expert witness on marine mammal ecology and/or potential impacts of noise on marine mammals for the following consent applications:

(a) On behalf of TTRL for its 2014 marine mining consent application to the New Zealand Environmental Protection Authority (EPA);

(b) On behalf of DOC in regard to the 2014 Chatham Rock Phosphate (CRP) marine mining consent application to the EPA;

(c) On behalf of OMV New Zealand Ltd for its 2014 marine consent application to the EPA for the Maari Field Development drilling programme; and

(d) On behalf of Shell Todd Oil Services Limited's (STOS) for its 2015 marine consent application to the EPA for the Māui Field and drilling operations.

6. I am presently employed as a Senior Research Scientist at Blue Planet Marine, an environmental consultancy company based in Nelson. Previously, I have worked as a Marine Mammal Scientist for 11 years at DOC and a further three and a half years at the Australian Government's Marine

Mammal Centre. I have been a member of the Scientific Committee of the International Whaling Commission since 1998 during which time I have held the positions of Head of the New Zealand delegation for eight years, Chair of the Southern Ocean Whales sub-committee for three years and a member of the Australian delegation for several years. I am also an Executive Officer of the South Pacific Whale Research Consortium, a member of the Convention on Migratory Species Scientific Council's Aquatic Mammals Working Group and a member of the New Zealand Threat Classification System team for marine mammals run by DOC.

7. I have more than 40 peer-reviewed research papers and three book chapters published in the international scientific literature. These include papers on nine different New Zealand marine mammal species, namely New Zealand sea lions, whales (sperm, humpback, southern right and blue) and dolphins (Hector's, Māui, dusky and bottlenose). I have also authored more than 80 unpublished research reports.

Code of conduct

8. I confirm that I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note dated 1 December 2014. I agree to comply with this Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

SCOPE OF EVIDENCE

9. In this Statement of Evidence, I will:

   (a) Provide an overview of:

i. marine mammal status, distribution and abundance in the Taranaki region;

ii. recent scientific evidence of the effects of noise on marine mammals;

iii. recent national and international "best practice" guidelines for mitigating potential impacts of noise on marine mammals;

iv. potential impacts of noise from the proposed activity;

(b) Give my professional opinion on the potential impacts of noise on marine mammals from the proposed activity;

(c) Review the Baseline Environmental Monitoring Plan (BEMP) with specific focus on: (i) Marine Mammal Baseline Monitoring Plan; and (ii) Underwater Noise Baseline Monitoring Plan and give my view on how these will mitigate and/or reduce any potential impacts from the activity on marine mammals; and

(d) Respond to issues about marine mammals and potential impacts of noise raised by the EPA and other submitters on the 2016 TTRL application.

10. I note that I have not undertaken any field studies in relation to this proposal.

DOCUMENTS REVIEWED

11. The primary sources of information and data used in forming my opinion are relevant parts from the following documents:

(a) TTRL (2016) South Taranaki Bight Offshore Iron Sand Extraction and Processing Project Impact Assessment;

(b) MacDiarmid et al. (2015a) South Taranaki Bight Factual Baseline Environmental Report [Report 1];

(c) Torres et al. (2015b) Habitat models of southern right whales, Hector's dolphin, and killer whales in New Zealand [Report 4];

(d) MacDiarmid et al. (2015b) Assessment of the scale of marine ecological effects of seabed mining in the South Taranaki Bight [Report 17];

(e) Aquatic Environmental Services (2016) Trans-Tasman Resources Ltd consent application: Ecological assessments [Report 20];

(f) Cawthorn (2015) Cetacean Monitoring Report [Report 24];

(g) Hegley (2015) Offshore Iron Sand Extraction and Processing Assessment of Noise Effects [Report 28];

(h) Findlay (1996) the Impact of Diamond Mining Noise of marine mammal fauna off Southern Namibia [Report 36];

(i) Institute for Maritime Technology (1994) Environmental Impact Study: Underwater Radiated Noise [Report 37];

(j) Institute for Maritime Technology (1995) Environmental Impact Study: Underwater Radiated Noise [Report 38]; and

(k) TTRL Marine Consent Application – Joint Statement of Experts in the Field of Effects on Marine Mammals including Noise - Noise Conditions. 26 March 2014.

12. These primary documents have been supplemented by my own experience and information from a wide variety of

sources used to summarise what is known regarding marine mammals in the region and the potential effects of noise on marine mammals.

13. I have also referred to a number of other additional reports in relation to the distribution, number and ecology of marine mammals in the STB. A list of these reports is contained in the next section.

MARINE MAMMALS IN THE SOUTH TARANAKI BIGHT

14. Information about the distribution, number and ecology of marine mammals in the STB, is contained in: TTRL (2016), MacDiarmid et al. (2015a, b), Torres et al. (2015b) and Cawthorn (2015). I note that these documents include reports of primary survey work (e.g. aerial surveys), habitat modelling, assessments of ecological effects and literature reviews.

15. These documents identified that the proposed mining area is used by very few marine mammals and then only infrequently. In particular:

    (a) Cawthorn (2015) which undertook dedicated and systematic aerial surveys of the proposed mining area for marine mammals every 2-3 months for over two years, only had one sighting of common dolphins and four sightings of fur seals. No evidence of Māui or Hector's dolphins was found within the proposed mining or in-shore areas.

    (b) Torres et al. (2015b) which concluded that habitat suitability for Hector's dolphins (as a surrogate for Māui dolphins) in the proposed project area was low but that coastal areas inshore of the proposed project area were predicted to have greater suitability as habitat for Hector's dolphins – although this does not mean that dolphins will necessarily be

found there. Currey et al. (2012) found that Māui dolphin density was less than 0.0005 Māui dolphin per square nautical mile inshore of the proposed mining area.

16. MacDiarmid et al. (2015a) provide a reasonable overview of marine mammals (excluding fur seals) in the STB but is now somewhat dated (e.g. the original report appears to be from 2011 and the most recent sighting data used is from 2008). It is not clear if this data set includes stranding and fisheries bycatch data and, if it doesn't, then it should be updated to include these. While there has been a reasonable amount of marine mammal survey activity since 2008, I don't believe that any of the conclusions would be significantly different if the more recent data was included. However, it would be useful to update this information to 2016 (which could be undertaken as part of the proposed baseline monitoring) as it is possible that some new species may be detected although, given the inherent limitations of this data set (e.g. non-systematic surveys), any conclusions other than that if a new species is present in the area will be limited.

17. MacDiarmid et al. (2015a) list species likely to be present in the STB region. This requires some updating with the possible addition of several new species (e.g. Hector's dolphin, pygmy right whale, beaked whales) and the re-classification of some other species (e.g. Bottlenose dolphins is now *Nationally endangered*). The only endangered species found in the region are Māui dolphin, Hector's dolphin, bottlenose dolphins and killer whales (now excluding southern right whales which are no longer listed as endangered).

18. Torres et al. (2015b) used sighting and survey data from up to 2011 to model habitat suitability for three endangered marine mammal species that are found in the STB (although I

note that southern right whales have now been relisted to a lower threat status from *nationally endangered* to *nationally vulnerable* meaning they are no longer endangered). The research concluded that the proposed project area in the STB appears to be of low suitability for all three species of threatened cetaceans. While the modelling approach has some limitations (e.g. use of primarily non-systematic survey data and observer effort bias), the general conclusions are consistent with my understanding of the ecology of these three species. It is also worth noting that this model only used data up until 2011 and since this time there have been extensive new aerial surveys for Hectors dolphin around the South Island that suggest a more offshore distribution than previously thought (MacKenzie & Clement 2014, 2016). It is not clear how this model might be sensitive to the introduction of this new data and whether it would change estimates of habitat suitability.

19. Cawthorn (2015) reported on 12 aerial surveys undertaken every 2-3 months between July 2011 and September 2013 for marine mammals over the proposed mining area and adjacent inshore waters. The survey detected six common dolphins and 10 New Zealand fur seals during over 8,400 km of transects and concluded that the abundance of marine mammals in the area is very low. The basic survey methodology was reasonable and it is likely that marine mammals with short dive times would have been observed if they had been present.

20. TTRL (2016) briefly summarises all the information on marine mammals provided in the application and also references previous consensus agreements from the Joint Expert Conferencing from the TTRL application in 2014 (i.e. Section 3.7). The report states in summary that there have been relatively few cetacean sightings around Taranaki but also

notes that the data set used to reach this conclusion is presence only data (i.e. almost exclusively from systematic surveys) but also notes that because a species has not been reported does not necessarily mean that it does not frequent these waters[1].

21. The list of species present in the region comes from MacDiarmid et al. (2015a) and, as noted above in paragraph 16, only used data up until 2008. It would be useful to update this based on data up to 2016 (which could be undertaken as part of the proposed baseline monitoring) but with the important caveat that just because a species has been reported in the Taranaki region does not mean that it is necessarily present in the proposed mining area or provide any information about the potential importance of the mining area to that species.

22. There are some areas where new and potentially relevant information has not been referenced or has become available since the summary of marine mammals provided in MacDiarmid et al. (2015a) and TTRL (2016). In addition to the above reports, I am aware of several other reports which contain potentially relevant information that I have reviewed in preparing my evidence:

    (a) There have been several key new reports on Hector's dolphins (e.g. MacKenzie & Clement 2014, 2016). While these reports are based on aerial surveys from the South Island, they do include information about survey work around the top of the South Island and West Coast. They also provide detailed information about the offshore distribution of Hector's dolphin. While this information is from well outside the

[1] TTRL (2016) South Taranaki Bight Offshore Iron Sand Extraction and Processing Project Impact Assessment. Section 3.7 page 54.

proposed mining area, the information is useful in informing any discussion around the potential use of the South Taranaki Bight by Hector's dolphins and may also have some useful parallels with Māui dolphins;

(b) Baker et al. (2016) which contains new draft abundance estimates for Māui dolphin;

(c) DOC (2016) contains dedicated sighting surveys for Māui dolphins in the South Taranaki area;

(d) Berkenbusch et al. (2013) provides a summary of the sighting records and also incidental capture records of marine mammals in New Zealand commercial fisheries (including the Taranaki area);

(e) Evidence supplied in OMV Maari Field and STOS Māui Platforms exclusive economic zone consent applications which both included detailed summaries of marine mammals in the regions (e.g. McConnell 2014, 2015);

(f) A range of new information (including over 150 new sightings from 2013-2016) is available about blue whales in New Zealand and the Taranaki region including Olsen et al. (2016), Torres et al. (2015a), Childerhouse et al. (2015) and Miller et al. (2014). These new data identify that (i) the STB is confirmed as a feeding area for blue whales and (ii) includes the first report of a mother nursing a calf in the region. However, I note that none of this information directly relates to the proposed mining area but is useful in further describing the broad scale habitat use patterns within the Taranaki region and increasing our understanding of the ecology of blue whales in the region;

(g) Baker et al. (2016) provides an updated threat ranking for marine mammals in New Zealand. Most listings have remained the same but notably southern right whales have been moved to a lower threat status from *nationally endangered* to *nationally vulnerable*;

(h) Derville et al. (2016) described the nearshore distribution of Māui dolphin and their relationship with environmental features. It also provides new information about the relative habitat suitability of the west coast North Island for Māui dolphins, including the proposed mining area; and

(i) There are also now confirmed records of Hector's dolphin along the west coast of the North Island and therefore this species should now be included in the species list for the Taranaki region (Baker et al. 2016).

23. I also undertook a preliminary review of all the data available in the DOC Marine Mammal Sighting and Stranding database to November 2016 (DOC 2016). A summary of the available spatial data is presented in **Appendix 1**. This includes over 1,600 records of marine mammal sightings and strandings from over 40 different marine mammal species and includes over 150 sightings of blue whales.

24. Overall, while MacDiarmid et al. (2015a) and Torres et al. (2015b) are now a little out of date and would benefit from an update, in my opinion it is unlikely that these updates would substantially change what we know about marine mammals and how they use the proposed mining area. While data from these two reports are useful, they are limited in that almost all the data has been collected: (i) from outside the proposed mining area; (ii) are from non-

systematic surveys; and (iii) it is therefore unknown if these data are likely to be representative of the proposed mining area.

25. By contrast, Cawthorn (2015) undertook dedicated and systematic aerial surveys of the proposed mining area for marine mammals every 2-3 months for over two years and only had one sighting of common dolphins and four sightings of fur seals. These data are useful in making direct inference about the proposed mining area and, in my opinion, provide reasonable evidence that the area has few marine mammals that use the area infrequently.

26. Torres et al. (2015b) concluded from the modelling that habitat suitability for Hector's dolphins (as a surrogate for Māui dolphins) in the proposed project area was low but that coastal areas inshore of the proposed project area were predicted to have average to above average suitability as habitat for Hector's dolphin. While the inshore habitat may be suitable, it doesn't mean that dolphins will necessarily be found there and, in fact, aerial surveys of this region found no evidence of Māui or Hector's dolphins in either the proposed mining area or inshore waters (Cawthorn 2015). This is further confirmed by the Māui dolphin distribution as agreed by an expert panel who indicated that Māui dolphin density was less than 0.0005 Māui dolphin per square nautical mile inshore of the proposed mining area (Currey et al. 2012). I therefore believe that Māui or Hector's dolphins are highly unlikely to be found in proposed mining area or the inshore waters from this area.

27. With respect to other marine mammals (e.g. killer whales, southern right whales, bottlenose dolphins, fur seals) in the proposed mining area, I conclude that they are likely to be infrequent visitors most likely transiting through the area with

no evidence of the location being of any particular significance to any species.

ASSESSMENT OF EFFECTS

28. **Appendix 2** provides a description of Acoustic Terminology and Characteristics which I use in this section.

Noise from the proposed activity

29. Hegley (2015) notes that there have been no empirical measurements of the noise produced by this activity but based on review of similar operations, estimates that the Source Level (e.g. noise) is 172 dB re 1µPa at 1m (e.g. back calculated from measurements of the noise from a cutter suction dredge recorded in air). Hegley also states that if the noise is no more than 122 dB, it will be masked by ambient noise which he estimates as being 132 dB (e.g. from measurements collected in Lyttelton Harbour). He therefore concludes that noise from the operation will be masked by ambient noise at a distance of 300m from a suction dredge and 900m from a cutter suction dredge. TTRL (2015) note that these assumed levels of crawler noise are consistent with those reported by Institute of Maritime Technology (1994, 1995).

30. There are no empirical measurements available for the noise produced by the crawler unit. Hegley (2015) notes that 'no specific information is available on the noise level from the suction dredge' but that some empirical information is available from a similar unit in two reports by the Institute for Maritime Technology (1994, 1995). While these estimates are useful, it is not clear how similar the units described are to the actual dredge unit being proposed for this operation while noting that the proposed TTRL crawler unit is a significantly more modern piece of equipment it is also 20% larger than

the units described in Institute for Maritime Technology Reports (1994, 1995)[2].

31. With only indirect information about the noise from the dredge proposed for this operation, it is necessary to therefore make assumptions about the noise source as was also undertaken in Hegley (2015). This can be achieved from by reference to other dredges (such as cutter- or trailer suction types) and noise levels. Data and direct evidence of impacts are also available from other marine operations broadly similar to the proposed activity, including: Ainslie et al. (2009), Robinson et al. (2011) and Slade et al. (2013).

32. These studies report a Sound Pressure Level (SPL) of between 160-188 dB re 1 μPa^2m^2 during dredging operations. These values are consistent with the value reported by Hegley (2015) as 172 dB re 1 µPa @ 1m. For the purposes of my impact evaluation and given the actual SPL of the TTRL dredge is not yet known, I have adopted a conservative approach and use the higher end of the reported scale as the SPL, specifically 188 dB re 1 μPa^2m^2. This is also considered conservative as the TTRL dredge is a suction dredge whereas the other dredges considered are suction dredges with the addition of cutting heads or trailer units which would presumably increase the overall noise levels emitted.

33. The limited data available for dredging show that it is not as noisy as seismic surveys, pile driving or sonar; yet it is louder than most shipping and drilling, and as such should be viewed as a low-medium impact activity (Thomsen et al. 2009; Slade et al 2013). Based on previously recorded Sound Pressure Levels, dredging is likely to be audible to most

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[2] Paragraph 55. TTRL Marine Consent Application 2014 – Joint statement of experts in the field of effects on marine mammals including noise. 26 March 2014.

marine mammals over considerable distances (depending on conditions) of up to several kilometres from the source (Slade et al. 2013).

34. I also note that provision has been made in the proposed conditions to limit the noise levels of the activity and to measure and monitor noise levels (i.e. Condition 12).

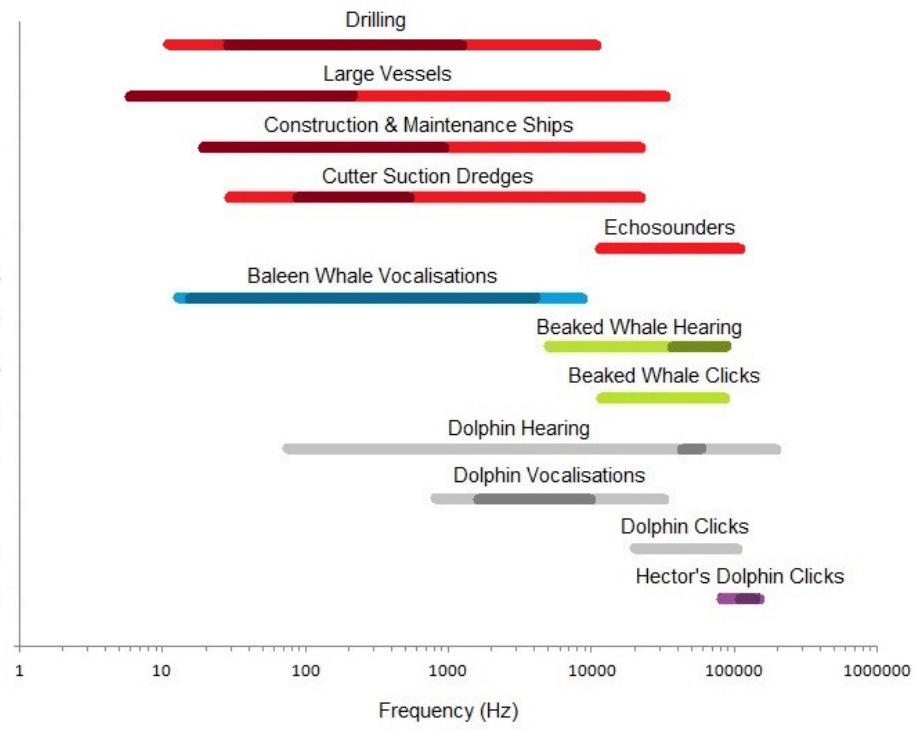
Marine Mammal Sensitivity to Noise

35. I have used data provided in TTRL (2016) and MacDiarmid et al. (2015a) as a basis for assessing which marine mammals are likely to be present in the proposed mining area and to assess sensitivity of those species accordingly.

36. Any noise with levels above the ambient background have the potential to mask (i.e. simultaneously interfere with) marine mammal communication systems, echolocation signals and passive listening capabilities (e.g. for predator avoidance), as well as to disturb normal behaviour resulting in possible displacement from habitat areas. There are no estimates of ambient noise levels available for the proposed mining area. However, I note that provision is made for obtaining these levels as part of the BEMP.

37. The greatest potential for masking and disturbance exists for groups of marine mammals that produce and/or perceive sounds within the frequencies dominated by the noise. **Figure 1** below provides a summary of the bandwidths and peak energy of different anthropogenic underwater noise sources and also marine mammal hearing and vocalisation ranges.

Figure 1: Comparison of marine megafauna[3] hearing ranges with anthropogenic sources.[4]



38. My assessment based on a review of the literature (as discussed in my paragraphs 29 to 34) is that the noise from the mining operation has a broadband energy profile at between 30 Hz to 20 kHz with the main frequency range within the 100-500 Hz band. Therefore, as can be seen from **Figure 1**, the broadband noise from mining will be potentially audible to baleen whales, beaked whales and dolphins with the main noise energy from mining overlapping with baleen whales and the lower frequency end of dolphin sensitivity. These overlaps indicate the potential for impacts from mining noise on marine mammals. As noted above, dedicated marine mammal surveys show very limited dolphin use of the

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[3] Darker sections of marine mammal hearing and vocalisation ranges indicate peak ranges (Johnson 1967, Kastelein et al. 2003, Mellinger et al. 2007, Popov et al. 2007, Houser et al. 2008, Nachtigall et al. 2008, Dawson 1990).

[4] Darker sections of anthropogenic sources of noise (red bars) indicate main energy ranges, echo sounders are variable (G□tz et al. 2009, Thomsen et al. 2009, CEDA 2011, Robinson et al. 2009).

proposed mining area and no evidence of any whales using the area.

Standards for anthropogenic noise

39. There are no New Zealand or internationally agreed standards for underwater noise. However, to put noise from the proposed mining operation in context, it is useful to examine examples of 'best practice' management of noise sources. Most of the available examples are from seismic surveys, which are considerably louder than noise from mining operations. Mining operations differ from seismic surveys in that they produce continuous, lower level noise at a single location for the duration of the programme (e.g. in this case for the full length of the consent) whereas seismic surveys produce pulsed, higher level noise across a broad survey area for the duration of the survey (e.g. generally weeks or months).

40. The 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (DOC 2013) provides national guidance on best practices for mitigation of seismic surveys in New Zealand. Again, while this document is specific to seismic surveys, many of the underlying ideas are applicable to any other source of noise. The Code sets two noise threshold levels to which seismic operations must adhere. The first threshold level is designed to minimise behavioural changes to marine mammals and limits Sound Exposure Levels (SEL) to less than or equal to 171dB re 1µPa^2-s at 1,000m from the acoustic source (behavioural criteria). The second threshold is designed to protect marine mammals against physiological injury and limits SELs to less than or equal to 186dB re 1µPa^2-s at 200m from the acoustic source (injury criteria). These SELs are not to be exceeded. If they are, then consideration must

be given to either extending the radius of the mitigation zone or limiting acoustic source power accordingly.

41. The U.S. National Marine Fisheries Service (NMFS) uses a 180dB re 1µPa SPL for predicting injury to baleen whales from exposure to impulse noise (NOAA 1998). The NMFS also uses a behavioural effect level of 160dB re 1µPa SPL based primarily on observations of baleen whale responses to airgun operations (NOAA 1998).

42. A previous application for a marine mining consent by TTRL, was considered by the EPA. A Joint Statement of Experts (including myself) in the field of effects on marine mammals including noise developed some draft noise conditions for TTRL's proposed sand mining operation which were agreed by consensus (one expert contributor did not sign). One of the conditions relating to possible noise thresholds was: "*The overall combined noise level at 500m shall not exceed 130dB re 1µPa RMS linear in any of the following frequency ranges: low frequency 10-100Hz, mid-frequency 100-10,000Hz, and high frequency >10,000Hz and that the overall combined noise level at 500m across all frequencies shall not exceed a sound pressure level of 135dB re 1µPa RMS linear*." I note that this text appears as proposed Condition 12 of the TTRL (2016) Impact Assessment.

43. Southall et al. (2007) is generally considered to be the definitive work in this field and is widely referred to in the international literature. This work also describes and defines noise threshold levels at which marine mammals are likely to show behavioural or physiological effects. Finneran and Jenkins (2012) provide an updated and slightly revised analysis of Southall et al. (2007) and provide criteria and thresholds for marine mammals for US Navy operations using weighted SELs. Perhaps given their recent publication, the

Finneran and Jenkins (2012) levels have yet to be widely used.

44. Based on a review of the available material, I consider that the best approach is for the likely noise level from TTRL operations to be assessed against the Southall et al. (2007) and Finneran and Jenkins (2012) criteria to determine if any effects on marine mammals are likely. I do this in my evidence below.

Assessment of potential effects from the proposed activity on marine mammals

45. The three types of potential impact from noise considered were, in decreasing order of severity:

    (a) Permanent threshold shifts (PTS), which result from unrecoverable tissue damage that leads to a permanent reduction in hearing sensitivity to sounds over a specific frequency range;

    (b) Temporary threshold shifts (TTS), which result in a temporary reduction of hearing sensitivity; and

    (c) Behavioural response threshold shifts.

46. Ideally the noise criteria used to determine the threshold shift levels at various distances and duration of exposure are:

    (a) SPL (i.e. the physical intensity or 'loudness' of sound at a specific point) for the dredge; and

    (b) SEL, (i.e. the total noise energy produced from a single noise event) which include the effect of the exposure duration and which were determined from the SPL values.

47. The potential impacts of dredging noise on marine megafauna can be assessed using criteria and thresholds that have been estimated for hearing loss and behavioural

effects (Southall et al. 2007, Finneran & Jenkins 2012). The functional hearing range for different animal groups varies. The marine megafauna found in the area proposed for the TTRL dredging operations were classified into the following three functional hearing groups following international best practice:

(a) Cetaceans in the low-frequency hearing group (all mysticetes – baleen whales e.g. blue, southern right, humpback whales);

(b) Cetaceans in the mid-frequency hearing group (most odontocetes – toothed whales & delphinids; killer whales, dolphins, beaked whales (assumed not to be present)); and

(c) Cetaceans in the high-frequency group (porpoises and Hector's dolphins).

48. Following Southall et al. (2007), I used SPL values to assess behavioural response thresholds. Sound exposure over time could lead to hearing damage, and SEL values were used to assess PTS and TTS thresholds. The sensitivity of an animal to a particular sound will depend on its functional hearing range – different cetaceans have different ranges. A conservative approach was taken and compared non-frequency weighted SPL and SEL values for the dredges with the corresponding frequency-weighted thresholds for behavioural response, TTS, and PTS as provided by Southall et al. (2007) and Finneran and Jenkins (2012).

49. The following Table 1 provides noise threshold values for non-pulsed sounds used to explore potential impacts of noise. **Table 2** provides Maximum SPL and SEL estimated for the cutter suction and trailer suction dredges from the literature and thresholds for physical impacts on marine megafauna.

Table 1 Noise level thresholds for non-pulsed/continuous sounds

Function hearing group	Behavioural response SPL (dB re 1 µPa)	(Type II) Weighted TTS SEL (dB re 1 µPa^2·s)	(Type II) Weighted PTS SEL (dB re 1 µPa^2·s)
Low-frequency cetaceans	120*	178	198
Mid-frequency cetaceans	120 (140 beaked)	178	198
High-frequency cetaceans	120	152	172

* From Southall et al. (2007). All others from Finneran & Jenkins (2012).

Table 2 Maximum Sound Pressure Levels (SPL) and Sound Exposure Levels (SEL) estimated for the cutter suction and trailer suction dredges from the literature and thresholds for physical impacts on low and medium frequency cetaceans*

	SPL (dB re 1µPa)	SEL (dB re 1µPa^2.s)					
Distance from source (m)	Simple geometric spreading	1sec	10sec	10min	0.5hrs	1hr	3hr
1	188	188	198	216	221	224	228
200	142	142	152	170	175	178	182
500	134	134	144	162	167	170	174
1000	128	128	138	156	161	164	168
2000	122	122	132	150	155	158	162

* PTS = red shading in a cell; TTS = yellow shading in a cell; Behavioural effect shown in orange

50. Table 2 demonstrates that SPL (or noise intensity) declines with distance from the source. SEL (or total noise exposure) by comparison is a combination of noise intensity and exposure time as can be seen by the increasing estimates of SEL as exposure time increases.

51. A comparison of the behavioural noise thresholds in Table 1 with the sound pressure level at various distances as shown in Table 2 suggests that cetaceans may start to show a behavioural response (such as swimming away) at somewhere between 500 m (Hegley 2015 data) and 2,000 m (published data) from the dredge.

52. With respect to impact on hearing, a comparison of the TTS and PTS thresholds in Table 1 with the SELs at various distances as shown in Table 2 be made.

(a) Low and Medium frequency cetaceans: Exposure to dredging noise for as little as 10 seconds if it is within 1 m from the source (Hegley (2015) data) to much as 1-hour exposure at 200 m from the source (Published data) could lead to TTS. PTS could occur at 1 m from the source in as little as 10 seconds to 10 minutes; and

(b) High frequency cetaceans: There is little overlap in the frequency output from the operation with the known sensitivity range of high frequency cetaceans (i.e. Māui and Hector's dolphins) and therefore little or no impact is expected.

53. When considering these estimated exposure times by distance, it is also important to consider these theoretical values against the real world situation. For example, it is extremely unlikely that an animal could get within 1 m of the sound sources as the sound source is not a point discharge but is rather dispersed and distributed in space since the generators, winches, and suction are all dispersed over the 300 m length of the ship and between the surface and the sea-bed. Furthermore, a marine mammal would have to swim towards the source of noise to reach a point close enough where they may be physiologically impacted by it.

54. Overall, this quantitative assessment of the impacts of noise identifies the potential for behavioural responses occurring. It is also important to consider that the exact behavioural disturbance resulting from exposure to the source may be simply be a marine mammal changing swimming direction and moving around or away from the noise source. The area

over which behavioural disturbance may occur will vary depending on the exact source level of the operation. Overall, while the risk of behavioural disturbance is low to moderate, this effect will only be evident in the area immediately around the operation.

55. While TTS and PTS are theoretically possible, they are highly unlikely given the length of time and close approach a marine mammal would need to make to potentially be effected and therefore represents a negligible risk.

Cumulative impacts

56. With respect to cumulative noise impacts from the activity, I note that there has been significant oil and gas development (including production and drilling) in this region for several decades and therefore any marine mammals present in the area may be habituated to any noise or other impacts as has been speculated for sperm whales in the Gulf of Mexico (Jochens et al. 2008).

57. Given that any noise impacts will be restricted to the immediate area around the mining operation, there is little likelihood of any overlap with other potential impacts further afield and therefore overall cumulative noise impacts would be unlikely.

58. With respect to vessel noise, the noise from vessels associated with mining operations needs to be considered in light of all other vessel activity in the region. Given the busy shipping traffic through the Taranaki region, the additional vessel traffic noise from these operations is likely to only represent a marginal increase in overall noise levels. Furthermore, most vessel activity associated with this activity will generally at slow or very slow speeds which significantly reduce the amount of vessel noise generated.

RESPONSE TO SUBMISSIONS

59. Some issues related to marine mammals were identified in submissions. I have responded to some of the key marine mammal issues raised in submissions (grouped by topic) from the following submitters:

(a) L. DeVantier;

(b) Patea & Districts Boating Club;

(c) W. Sayer;

(d) J. Hubbard;

(e) A. Greig;

(f) P. O'Brien;

(g) N. Boheimer;

(h) New Plymouth Sportfishing & Underwater Club;

(i) Sea Shepherd NZ;

(j) Te Kaahui o Rauru;

(k) Forest & Bird (National Office);

(l) P. Grant;

(m) A. Smith;

(n) Cloudy Bay Clams;

(o) Nga Motu Marine Reserve Society;

(p) J. Edgar;

(q) D. Lilley;

(r) H. Ward-Jones;

(s) Waitotara Patea Surf Casting Club;

(t) Forest and Bird (Manuatu);

(u) Kiwis Against Seabed Mining;

(v) K. Pratt;

(w) Greenpeace; and

(x) Environment & conservation Organisations of NZ.

Significance of the proposed mining area to marine mammals

60. Cawthorn (2015) undertook dedicated aerial surveys for marine mammals every 2-3 months for over two years covering over 8,400 km of transects and only had one sighting of common dolphins and four sightings of fur seals. Cawthorn (2015) therefore concluded that the abundance of marine mammals in the area is very low. Torres et al. (2015) modelled habitat suitability for Hector's dolphins (as a surrogate for Māui dolphins), killer whales and southern right whales and concluded that the proposed project area appears to be of low suitability for all three species of threatened cetaceans. Based on these dedicated marine mammal monitoring and modelling projects of the proposed mining area, there is little to suggest that the proposed mining area is of significance to any marine mammal species as either an important breeding, feeding or resting area although it is likely that some marine mammals will move through the area occasionally.

61. One submission identified 117 new reports of killer whales in the Taranaki region from Project Hotspot (although it is not clear how many of these sightings may be duplicate reports of the same group) which does provide additional useful information for the region. However, there were no sightings made in the proposed project area and only 13 sightings were made in inshore waters along the south Taranaki coast

with almost all other sightings made to the north and/or west of Taranaki.

62. These reports are broadly consistent with the habitat suitability modelling for killer whales undertaken in Torres et al. (2015b) even though this analysis does not include the new sighting information. A submission also noted that killer whales are unlikely to be resident in the region but may remain in the area for several months. While this information is useful in assessing killer whale behaviour in the Taranaki region, it doesn't suggest that the proposed mining area represents a significant area for killer whales although they may move through the area occasionally.

Significance of the Greater STB to marine mammals

63. Various submitters commented on the importance of the Greater South Taranaki Bight to marine mammals including identifying species that are likely to be present in the region that were not recognised in the original application (e.g. pygmy right whales, Cuvier's beaked whales, Risso's dolphins). While information about marine mammals reported in the greater STB area are useful in providing a broad regional context, such data provides little specific information about the species that are likely to be found in the proposed mining area or the importance of that area to them. Given the specific marine mammal information available about the proposed mining area provided in Cawthorn (2015), MacDiarmid et al. (2015b), and Torres et al. (2015b), information about species found outside of this area are less informative but still useful as context.

Outdated and/or lack of information about marine mammals

64. Based on the assessment in TTRL (2016), thirteen species of whales and dolphins have been reported from the region but this is acknowledged as a minimum estimate as there

has been little systematic and dedicated marine mammal survey effort in the region. One submission noted that marine mammal stranding records had not been considered when developing this species list and that if strandings are included, then the total number of marine mammal species likely present increases to 33. Although, it was noted that all threatened and endangered marine mammal species were included in the original species list. This is useful additional information but stranding information can be an unreliable source of information about distribution as sick or dying individuals often stray outside of their normal range.

65. As noted in paragraph 16 of this Evidence, the data reported in MacDiarmid et al. (2015a) only utilises sighting data up until 2008. While there has been a reasonable amount of marine mammal survey activity since 2008, I do not believe that any of the conclusions would be significantly different if the more recent data was included. As noted in **Appendix 1**, my preliminary review of all the data available in the DOC Marine Mammal Sighting and Stranding database to November 2016 (DOC 2016) identified over 40 different marine mammal species and included over 150 sightings of blue whales. However, none of these new species identified are listed as threatened or endangered.

The Greater STB is an important feeding area for blue whales

66. The greater STB area is clearly an important feeding area for blue whales (and potentially only one of five known feeding areas in the Southern Hemisphere). During the most recent blue whale survey in January 2016, the closest record of a blue whale feeding to the proposed mining area was >110 km with most sightings even further west of Farwell Spit and/or Kahurangi Point (Torres et al. 2015a). Furthermore, a preliminary analysis of data available in the DOC Marine Mammal Sighting and Stranding database to November

2016 (DOC 2016), includes approximately 270 records of blue whales within in the STB region but of these only two blue whale records occur within 50 kms of the proposed mining area with the bulk of sightings further to west and offshore. Given the large distance away from the proposed mining area, there will therefore be negligible impact from the operation on blue whale feeding.

Inadequate baseline marine mammal surveys

67. Some submissions commented on inadequate baseline marine mammal survey data. As noted previously, Cawthorn (2015) undertook 12 dedicated aerial surveys of the proposed mining area for marine mammals over 2011-2013 and covered over 8,400 km of survey effort. This was complemented by an assessment of 187 whale and dolphin sighting records held by DOC and M. Cawthorn provided in MacDiarmid et al. (2015b). In addition, Torres et al. (2015a) undertook habitat suitability modelling for three species of threatened marine mammals. These projects provide a good baseline understanding of the likely marine mammals found in the area. While the stranding record wasn't included in this assessment which would have been useful, all the threatened or endangered species were identified in the absence of stranding data.

Inadequate description of the potential impact of noise on marine mammals

68. This area was covered by Hegley (2015) with additional specific detail provided in this Evidence. Based on this Evidence, where I took a highly conservative approach and assessed the impact of the loudest noise reported from dredging operations (e.g. which is considerably louder than what was considered by Hegley). I found that while there exists the potential for behavioural modification (e.g. exclusion from the area), given that the area over which the

noise will be audible is likely to be relatively small (e.g. an area potentially a maximum of several km around the source) the effect on individuals, let alone species in the STB, is likely to be extremely limited. There is a negligible risk of physiological hearing damage to any marine mammal species from this operation. Furthermore, any marine mammals that may be in the vicinity of the operation and are disturbed by noise, could move away at a rate much faster than that of the factory and crawler (i.e. 70 metres per hour).

69. Furthermore, TTRL have proposed Condition 12 that sets a limit on the noise produced by the operation which is identical to the draft condition developed by consensus by the Expert group on noise for the 2014 TTRL consent application and which I understand has also been endorsed by DOC as meeting their concerns regarding noise impacts on marine mammals.

There will be potential impacts on marine mammals from the discharge plume

70. Marine mammals could be potentially impacted by the discharge plume through a variety of mechanisms including increased turbidity leading to reduced foraging efficiency, reduced prey availability, habitat displacement and/or toxicity and bioaccumulation. These issues and potential impacts on marine mammals were covered in MacDiarmid et al. (2015b) which reported that there should be negligible effects of mining 50 Mt per annum according to standard evaluation criteria. This is principally because the scale of the mined area and the areas of elevated suspended sediment concentrations are small compared to the area used by the populations of these species. Consequently, they are likely to be displaced from, or experience a decrease in prey abundance or availability over a very small part of their

distribution. Furthermore, marine mammals are highly mobile and have ample opportunity to avoid the discharge plume.

The use of Admiralty Bay for shelter could impact on marine mammals

71. Operational vessels may seek shelter in Admiralty Bay upon occasion but there will be negligible impact on marine mammals as vessels will not be mining but simply sheltering for short periods as other vessels do. Dusky dolphins in Admiralty Bay are not present in the area all year round and recent research has suggested that (i) dolphins are spending less time in the area than they used to and (ii) the population size appears to be increasing (Clement & Halliday 2016).

PLANNING AND CONDITIONS

72. I note that the TTRL (2016) provide details of a proposed Monitoring and Management Framework. Some comments regarding this framework in relation to marine mammals:

    (a) A Technical Review Group will be established to provide technical oversight and advice to TTRL. I would recommend that this group includes expertise in marine mammals;

    (b) A Baseline Environmental Monitoring Plan (BEMP) has been proposed prior to the activity starting, including a monitoring programme for marine mammals and underwater noise. Both monitoring programmes have appropriate aims and cover the key aspects that would support increasing our understanding of both marine mammals in the area and any potential impacts on them. I note the inclusion of acoustic monitoring as a valuable step;

    (c) An Environmental Monitoring and Management Plan (EMMP) has been proposed and will ensure that any

project related effects are effectively and efficiently monitored and managed throughout the term of the project. There is also a specific marine mammal and underwater noise component to this plan. This will build on and complement the data collected during the BEMP studies and allow for an understanding of any potential changes in marine mammal behaviour and also an increased understanding of any potential impacts of the activity. Both the Marine Mammal Monitoring Plan and Underwater Noise Monitoring Plan provide excellent detail about the proposed programme and will provide useful data in increasing the understanding of marine mammals and detecting any potential impact of the activity. Again, I note the inclusion of acoustic monitoring as a valuable step which will confirm the actual noise levels from the operation to ensure that they are within the levels stated in the IA;

(d) A Marine Mammal Management Plan (MMMP) will also be developed that details how various management commitments not covered by the monitoring programmes will be addressed to ensure the specific requirements of the proposed consent conditions are complied with. This provides excellent detail of such activities as pre-start observations, soft start protocols, and the inclusion of at marine mammal observers on board operational vessels at all times which complements the EMMP. This is well developed and addresses all the areas that I would expect to see in a plan related to this activity.

73. Overall, these documents provide an excellent level of detail around proposed monitoring and management of marine mammals and noise from the proposed activity. I believe

that the data collected from these monitoring programmes will be adequate to detect and characterise any potential impacts on marine mammals from the activity subject to additional details being confirmed about the exact survey methods to be utilised.

74. There are a range of proposed conditions relevant to marine mammals and noise including 11, 12, 13, 14, 20, 49, 60, 61 and 78. These conditions provide good descriptions of a wide range of proposed monitoring and mitigation activities which I believe cover all of likely issues related to the activity. Some of the key areas include:

(a) Development of a MMMP with a goal of there being no adverse effects at the population level on most marine mammal species (Condition 11(a));

(b) One Marine Mammal Observer is on board each of the operational vessel (Condition 11(b));

(c) Vessels shall reduce speed when within 500m of large cetaceans (Condition 11(g));

(d) Some detailed underwater noise requirements limiting the noise output of the operation to specified levels (Condition 12):

i. The overall combined noise level at 500 m shall not exceed 130 dB re 1µPa RMS linear in any of the following frequency ranges: low frequency 10-100 Hz, mid-frequency 100-10,000 Hz, and high frequency >10,000 Hz; and

ii. The overall combined noise level at a nominal depth of ten (10) m below the sea surface and 500 m from the Integrated Mining Vessel, across all frequencies shall not

exceed a sound pressure level of 135 dB re 1µPa RMS linear;

(e) Soft starts to be used for all starts (Condition 60); and

(f) Pre-start observations to be undertaken for marine mammals prior to soft-starts (Condition 61).

75. Overall, I believe these conditions are appropriate to the low level of risk posed by the proposed mining activity for marine mammals. Also, as noted above, I understand that DOC agrees with these conditions.

Dr Simon John Childerhouse

15 December 2016

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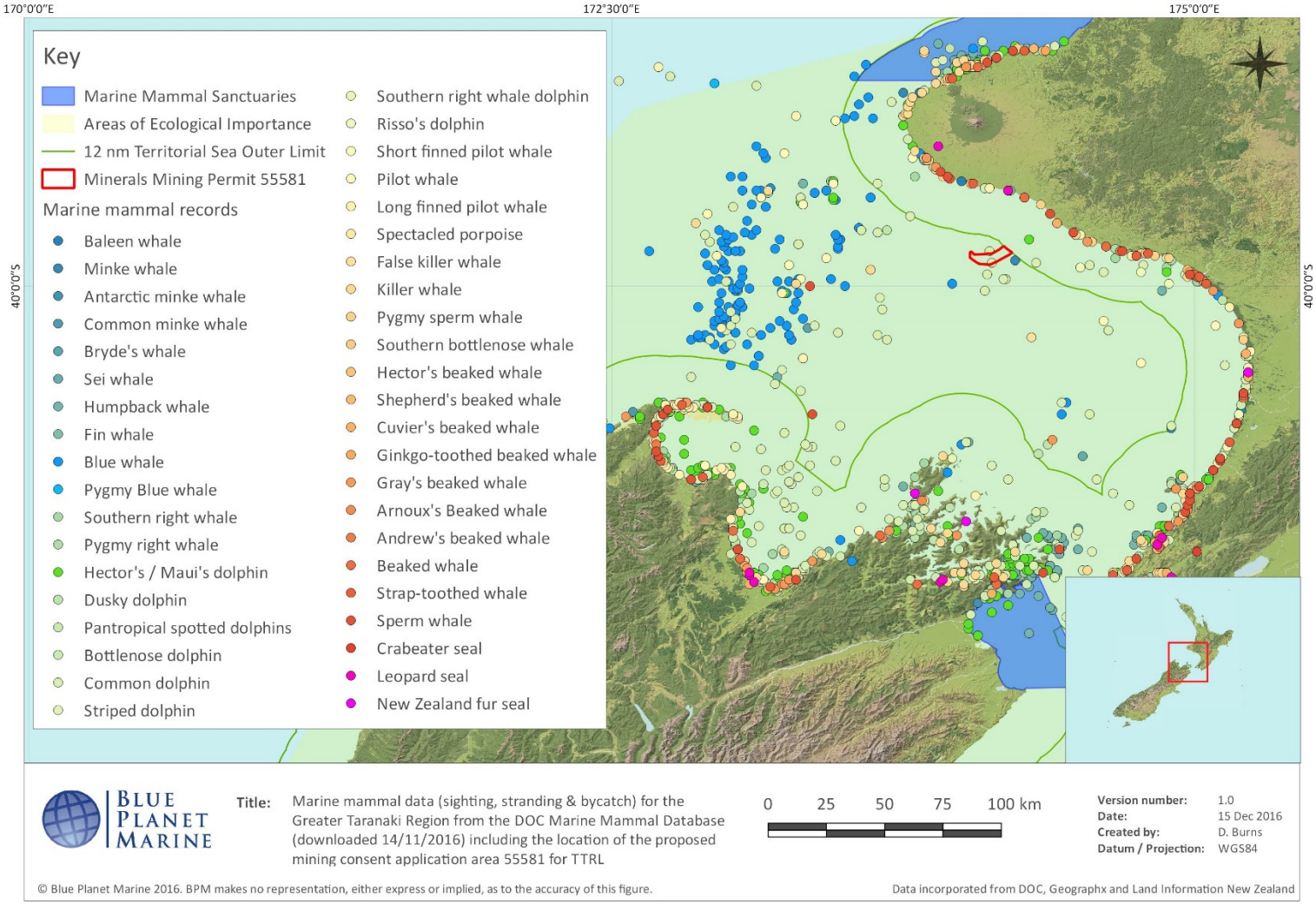
APPENDIX 1 – PRELIMINARY ASSESSMENT OF MARINE MAMMAL SIGHTING AND STRANDING DATA FOR TARANAKI FROM THE DOC MARINE MAMMAL DATABASE TO NOVEMBER 2016



APPENDIX 2 – ACOUSTIC TERMINOLOGY AND CHARACTERISTICS

Acoustic terms used are as follows:

- Decibel (**dB**) - the unit of sound intensity/pressure level measured on a logarithmic scale (e.g. an increase in acoustic energy of 10dB leads to an increase by a factor of 10, an increase of 3dB corresponds to a doubling of power);
- Sound Pressure Level (**SPL**) - indicative for the average amount of sound at one location (which is generally described as a distance from the source of the sound);
- Source Level – Acoustic pressure at a standard reference distance of 1m. Units in dB re1µPa (micropascal) at 1m (i.e. the 'loudness' of sound emitted from a source);
- Sound Exposure Level (**SEL**) - indicative for the total amount of sound energy at one location over a certain time duration;
- Root Mean Square (**RMS**) - the mean variance of continuous waveforms (often loosely referred to as the "mean power") of continuous waveforms. This is the generally accepted metric in describing sound from a continuous sound source (e.g. production or drilling);
- Spectrum - describes how the power of a signal is distributed with frequency (i.e. what range of frequencies make up the overall sound);
- Broadband - a sound that is comprised of a wide range of frequencies with a large bandwidth (i.e. bandwidth is the width of such a frequency band, that is, the highest frequency minus the lowest frequency); and
- Peak energy – the part of the frequency bandwidth with the highest intensity/pressure levels.

A major difference between underwater and above water sound measures is that the amplitude of the reference pressure variation of

underwater sound is by definition 1µPa (versus 20µPa in air). This difference is an important cause of misunderstandings (e.g. when comparing above-water sound levels with underwater sound levels. Both are expressed in dB, but with respect to a different reference level and are not directly comparable) By definition, the reference pressure of sound in water is 1µPa (i.e. 1µPa corresponds to 0 dB). (Ainslie et al. 2009).

The basic concepts of sound in the underwater environment are very similar to that in air. However, the medium 'water' supports the propagation of sound even better than the medium 'air'. In water, the attenuation is less than in air. This means that sound propagates over longer distances underwater than in air. It also propagates much faster: the speed of sound in water is approximately 1500m/s versus 340m/s in air.