BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY
AT WELLINGTON

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 ("the Act")
AND	
IN THE MATTER	of the applications by Trans Tasman Resources Limited (TTR) for marine and discharge consents to recover iron sand under sections 20 and 87B of the Act and
BETWEEN	**Trans-Tasman Resources Limited** Applicant
AND	**The Environmental Protection Authority** EPA
AND	**Kiwis Against Seabed Mining Incorporated (KASM)** Submitter

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STATEMENT OF EVIDENCE BY PROFESSOR ELISABETH SLOOTEN ON BEHALF OF KIWIS AGAINST SEABED MINING INCORPORATED

Dated 24 January 2016

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STATEMENT OF EVIDENCE OF ASSOCIATE PROFESSOR ELISABETH SLOOTEN

Qualifications and experience

1. My name is Elisabeth Slooten. I am a Professor in the Department of Zoology at the University of Otago in Dunedin, where I have worked since 1990. I have undertaken extensive research on marine mammals in New Zealand coastal waters since 1984, including research on New Zealand dolphins (Hector's and Maui dolphins), bottlenose dolphins, sperm whales, right whales and New Zealand sealions.

2. I hold Bachelor of Science and Master of Science (first class honours) degrees in Zoology from Auckland University, and a PhD in Zoology from Canterbury University.

3. My research includes population surveys to study the abundance and distribution of marine mammals, estimation of survival and reproductive rates, behavioural research, population viability analyses and risk analyses to quantify the impact of fishing, tourism and other human activities on marine mammals. The population survey work includes boat surveys, aerial surveys using planes and helicopters, acoustic surveys using towed hydrophone arrays, directional hydrophones and passive acoustic data loggers. I was invited to join an overseas, large-vessel, whale and dolphin survey in order to train scientists from the United States National Marine Fisheries Service in the use of some of these techniques.

4. I have published two books, more than 100 peer-reviewed papers in scientific journals, chapters in scientific books, encyclopedia chapters and over 50 invited or contracted reports and papers on these topics. The books and more than 45 of the published papers have been specifically on the biology, behaviour and conservation biology of the New Zealand (Hector's and Maui) dolphin.

5. I am the co-director of the Otago University Marine Mammal Research Group. Other researchers in this group also directly involved in research on Maui and Hector's dolphin include Professor Steve Dawson (Head of Marine Science Department at Otago University), Dr William Rayment (Lecturer in Marine Science Department at Otago University), Trudi Webster, Tom Brough, Marta Guerra-Bobo, Maddalena Fumagalli and David Johnston.

6. I was awarded the Sir Charles Fleming Award for outstanding contribution to environmental science in 2004, by the Royal Society of New Zealand. This award is made once every three years, and was awarded to me jointly with Professor Stephen Dawson.

7. I was awarded the Professor John Morton Award for outstanding contribution to marine science in 2016, by the New Zealand Marine Sciences Society.

8. I have represented New Zealand on the Scientific Committee of the International Whaling Commission (since 1992) and am a member of the Cetacean Specialist Group of the IUCN (since 1991). I am regularly invited to examine PhD theses from New Zealand and overseas universities, invited to participate in national and international conferences and workshops about marine mammal science and threats to marine mammal populations, and invited to referee scientific publications in New Zealand and international scientific journals. I am currently the Vice President of the New Zealand Marine Sciences Society and have been its Secretary and President in previous years. I am regularly commissioned by government departments and commercial clients to carry out research on the potential impacts of human activities on marine mammals. I chaired the organising committee for a major international conference of the Society for Marine Mammalogy held at Otago University in 2013.

9. I teach graduate and undergraduate courses at Otago University on the biology of marine mammals, marine vertebrates, marine conservation biology, ecology, population viability analysis and statistics. I have supervised more than 50 graduate student projects, including 17 MSc and 20 PhD projects. My role at the University of Otago has included setting up and being the Director of a graduate programme in Environmental Science.

10. I have previously provided expert evidence at Regional Council Hearings, Environment Court Hearings, three previous Environmental Protection Authority hearings and other Expert Panels and Advisory Panels.

11. I confirm that I have read the 'Code of Conduct for Expert Witnesses' as contained in Schedule 4 of the Judicature Act 1908 and the Environment Court Consolidated Practice Note 2011. I agree to comply with these Codes of Conduct. Except where I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Evidence on Proposed Marine Mining Operation by TTR Limited

12. *Introduction:* My evidence includes consideration of: a) Poor information provided on marine mammals present in the area; b) Direct impacts on marine mammals; c) Lack of information on the noise generated by the proposed mining operation and its potential impact on marine mammals in the area d) Problems with the estimate of background noise; e) Ecosystem effects of the proposed mining activity; f) Conservation implications and cumulative impacts and g) Problems with the proposed monitoring plan.

13. *Presence of marine mammals in the area:* Insufficient information has been provided on the numbers and species of marine mammals in the area, as well as their likely reactions to the noise, habitat destruction, sedimentation and flow-on ecological impacts associated with the proposed mining operation. The information provided by TTR includes a population survey which is inadequate for the purpose, and some habitat modelling based on anecdotal information.

    13.1 Problems with the TTR survey include the small size of the area covered and a lack of data on sighting probability. The fact that only the two most common marine mammal species were sighted (common dolphins and fur seals) is indicative of low sighting probability rather than indicative of low marine mammal presence in the area.

    13.2 The lack of comprehensive, systematic marine mammal surveys in the Cook Strait area also hampers habitat modeling work. The habitat modeling carried out for TTR is based on anecdotal information including public sightings rather than the results of systematic, scientific surveys. Derville et al. (2016) used a more comprehensive approach, analysing recent and historical sightings of Maui dolphins. They concluded that the area of suitable habitat for Maui dolphin is much larger than the area that Maui dolphins currently occupy. This is consistent with other research (e.g. Russell 1999) indicating that the current range is much smaller than the original range of Maui dolphins, which included at least the area from Whanganui to Raukokore Bay (Bay of Plenty) and potentially the Hauraki Gulf (Derville et al. 2016). A comprehensive analysis of the current and historical range of Maui and Hector's dolphins would also need to include anthropogenic factors limiting population growth and habitat re-colonization (including fishing, seismic surveys and other marine mining activities). These appear to be more important in reducing the range of Maui and Hector's dolphins than sharks or other predators. For example, historical records show that Hector's dolphins were much more abundant off the Otago coastline in the 1800s than currently (e.g. Diver 1866). A comprehensive model of

Hector's and Maui dolphin habitat should include layers of fishing effort and other anthropogenic effects, in addition to natural environmental variables. For now, the available information on habitat preferences indicates that a wider area will need to be protected in order to allow Maui dolphin to recover from Critically Endangered to Endangered and eventually to non-threatened status (e.g. Derville et al. 2016). At a minimum, the area from Maunganui Bluff to Whanganui, to 20 nautical miles offshore, as recommended by the Scientific Committee of the International Whaling Commission (IWC 2012-2016).

13.3 Publicly available data show that there are at least 33 marine mammal species use the Cook Strait area. All 9 baleen whales found in New Zealand waters use the area. In addition, 24 species of toothed whales, including dolphins, sperm whales and beaked whales, are known to occur in Cook Strait. For more detailed information, please see Anton van Helden's evidence (van Helden 2017).

14. *Direct impacts on marine mammals:* The potential impacts of sand mining include noise (discussed in detail below), collisions with vessels and mining equipment, habitat damage (including habitat destruction within the mining area and the sediment plume extending well beyond the mining area) and pollution such as from antifouling agents and oils. The potential physical impacts on marine mammals, include injury and hearing impairment. Behavioural responses include displacement and stress (Forney et al. 2016).

14.1 When assessing potential impacts, it is important to consider the behaviour of the marine mammals at the time (e.g. feeding) and whether individuals are pregnant or accompanied by calves. These are important considerations, because stress-related changes in adrenal and thyroid hormones levels have been documented in cetaceans (e.g. Dierauf 1990; St. Aubin and Dierauf, 2001) and stress hormones vary between sex and age classes (St. Aubin et al. 1996).

14.2 Like in most other vertebrates, stress can alter immunocompetence in cetaceans (Edwards 2007). Haematological and biochemical changes in response to stress have been documented in bottlenose dolphins (Geraci and Medway 1973) and in a Bryde's whale entrapped in a river in southern Australia (Priddel and Wheeler 2006).

14.3 The effects of noise on marine mammals include physiologically induced and behaviourally induced impacts (e.g. Nowacek et al. 2007; Childerhouse evidence for TTR). Physiological effects of noise include direct damage to organs and tissues, permanent or temporary hearing threshold shifts and stress. There is considerable potential for disturbance. For example, sperm whales and beaked whales use the Cook Strait area and are very sensitive to noise disturbance and can suffer injury or death from stranding or rapid ascent during diving, in response to noise. Blue whales which use the area year round are susceptible to low frequency noise in particular (e.g. Torres 2017). Maui dolphins which are found immediately inshore of the proposed mining operation are Critically Endangered. Any noise pollution in the area, including seismic surveys and mining risks displacing these endemic dolphins into high risk areas and increasing the impact of other human activities, including fishing (Forney et al. 2017). Stress can cause delayed mortality in dolphins (e.g. after bycatch in purse-seine fisheries) and these mortalities are thought to be important at the population level (Edwards 2007).

14.4 Prolonged or repeated stress can increase susceptibility to other threats and impair immune function (e.g. Wright et al. 2011). Growing human activity in the marine environment is increasing the frequency with which human disturbance triggers stress responses in marine fauna and therefore the likelihood of inducing chronic stress. Sound travels faster through water than air, and low frequencies can travel many tens of kilometres with little loss in energy. Marine fauna will therefore be acoustically exposed to human activity at much greater distances than terrestrial animals. Coastal species, like Maui dolphins are especially vulnerable due to the concentration of human activity in these areas. Maui dolphins are already subject to a host of synergistic and potentially cumulative stressors that may be further aggravated by the effects of noise and other impacts associated with marine mining (Forney et al. 2017). The mechanism of the stress response to noise involves activation of the pituitary-adrenal-cortical axis and the sympathetic-adrenal-medullary axis. Changes in stress hormones, including epinephrine, norepinephrine and cortisol are frequently found in acute and chronic noise experiments, affecting the animal's metabolism. Whales and dolphins are highly vocal and dependent on sound for almost all aspects of their lives, e.g. food-finding, reproduction, communication, detection of predators/hazards, and navigation and therefore sensitive to anthropogenic noise.

14.5 Displacement of marine mammals from the affected area, whether due to habitat damage, noise or the sedimentation plume, may result in displacement from important feeding areas and/or may increase the displaced animals' exposure to threats such as predators or entanglement in fishing gear (Forney et al. 2017). This is particularly critical for endangered and critically endangered species.

15. *Noise:* TTR have failed to provide either measurements of the noise made by the proposed mining operation (ships, generator and dredge to be used) or measurements of the background "ambient" noise off Taranaki.

15.1 Permanent and temporary deafness of marine mammals (permanent and temporary threshold shifts) tend to occur relatively close to the noise source, as indicated by Childerhouse (Evidence for TTR). However, behavioural impacts, masking and stress responses can occur over a much wider range (e.g see Hatch et al. 2012).

15.2 The effects of noise on marine mammals include physiologically induced and behaviourally induced impacts (Nowacek et al. 2007). Physiological effects of noise include direct damage to organs and tissues, permanent or temporary hearing threshold shifts and stress (e.g. Finneran et al. 2000, Popov et al. 2013). Behavioural effects of human-made noise include disruption of activities, exclusion from habitat and masking of vocalisations or interference with communication and echolocation (e.g. McCarthy et al. 2011, Castellote et al. 2012, Iorio and Clark 2010, Nieukirk et al. 2012, Tyack et al. 2011, DeRuiter et al. 2013, Goldbogen et al. 2013, Dunlop et al. 2013).

15.3 Accurate information on the loudness and frequency spectra of the noise generated by the proposed mining operation are required, before impacts on marine mammals can be assessed. Insufficient information has been provided, and the small amount of information that is available is unreliable. This makes it impossible to determine the noise levels and frequencies produced by the proposed operation or to predict how this noise will propagate in the area proposed for mining.

15.4 Dr Simon Childerhouse from Blue Planet Marine Ltd has had to rely on noise made by other "broadly similar" dredging operations in his evidence for TTR. He explains that the amount of noise produced depends on the particle size of the material being extracted, with gravel producing more noise than sand. The frequency of the sound also depends on particle size, with coarse and very coarse sand (0.5-2mm particle size) producing substantial noise in the 20-168 kHz range. Robinson et al. (2011) describe the noise made by mud, sand and/or gravel moving through the suction pipe and through the pump as a "high frequency broadband 'hiss'" with a smaller component of the high frequency noise being due to the pump itself.

15.5 The report prepared for de Beers mining in Namibia does not provide scientifically robust information on how much noise (loudness), and what kind of noise (frequencies) will be produced by the dredge to be used by TTR. Coley (1995) did not record the high frequency sound produced by the navigation transponder, instead using noise levels from the manufacturer's manual, and stated that these short pulses are difficult to record. In fact, such sounds are routinely recorded by marine mammal scientists. Coley (1995) did not use broadband recording equipment. Therefore, in addition to reporting on a different dredge Coley (1995) provides incomplete information on the sound produced (up to 60 kHz). The drop off at high frequencies, seen in Coley's figure 6 is most likely due to the limitations of the recording equipment rather than a lack of high frequency noise produced by the dredging operation. The transponder navigation system is unlikely to be the only source of high frequency noise. Noise produced by the pump and crawler will also include high frequency components. In addition, the collision of sand grains generates high frequency noise.

15.6 Measurements of background noise provided by TTR are not credible. Hegley's Evidence for TTR describes measurements of ambient noise at Lyttelton Harbour for 15 minutes. This is not an appropriate site for evaluating noise levels off Taranaki. At the last hearing, Hegley provided sound recordings from Taranaki, but these were subsequently found to be erroneous. The sound files were provided several months after the hearing and were found to be corrupted.

15.7 Ambient ocean noise is highly site specific. Sound propagation depends strongly on underwater topography, benthic substrate and water temperature (Estabrook et al. 2016). In addition, ambient ocean noise varies through time with strong daily and seasonal patterns (Estabrook et al. 2016). These factors need to be carefully considered and scientifically robust recordings of ambient noise at the proposed mining site made before the level of potential disturbance to marine mammals can be assessed. Hegley speculates that noise caused by mining activities will be less than the ambient noise levels, and therefore not impact marine life. This conclusion is erroneous for several reasons, including the lack of relevant recordings of ambient noise with which to compare the noise level of the proposed mining operation.

15.8 Hegley's conclusions about sound levels in Lyttelton Harbour also appear to be in error. Like his recordings for Taranaki in 2013, the sound levels he claims to have recorded at Lyttelton Harbour are surprisingly high. For example, ambient noise recordings in a range of weather conditions in Fiordland do not exceed 100 dB re: 1μPa unless there is considerable boat noise (Dawson et al. 2005). A background noise level of 129 dB would have 1000 times the energy level of the loudest natural levels of ambient noise in Fiordland. For similar data from overseas, see Hatch et al. (2012) and Williams et al. (2013). The evidence provided by Dr Torres (2017) discusses the problems with Hegley's conclusions about ambient noise in more detail. I agree with her conclusion that noise assessments must be carried out at the proposed mining site, so local ambient noise conditions can be measured and a representative transmission loss model can be developed.

15.9 The absence of credible, scientifically robust data on background noise and the noise produced by the mining operation mean that it is not possible to determine the impact of the noise from the proposed mining operation on marine mammals, nor to develop conditions relating to noise. Simple threshold criteria based on exposure level are not useful (Melcón et al. 2012, Risch et al. 2012, Ellison et al. 2012, Castellote et al. 2012, Robertson et al. 2013). Likewise, assessments of a species' sensitivity based on the sounds it produces have been shown to be simplistic. For example, harbour porpoise are now known to react to shipping noise, which has most of its energy in the low frequency range and has until recently been thought to be of relatively little importance for harbour porpoise, Maui dolphins and other species that produce high frequency sounds (Dyndo et al. 5015).

15.10 To put the noise impacts into context, ocean noise around the world has been increasing over the last few decades due to industrial activities such as vessel traffic, seismic survey operations and mining activities, and sonar (Hildebrand 2009). This has resulted in significant impacts on cetaceans (e.g. Tyack 2008, Clark et al. 2009). For example, blue whales worldwide have shifted their frequency of communication over the past five decades (McDonald et al. 2009). The TTR impact assessments state that whales and dolphins may avoid the mining operation in response to noise and other disturbance. This would be a serious impact. Habitat displacement can have significant consequences if whales and dolphins miss important feeding or mating opportunities as a consequence, or if the displacement results in the animals coming into increased contact with other threats (Forney et al. 2017). The long duration of the proposed mining operation is a serious concern in this regard.

16. *Ecosystem effects:* The potential impacts of the proposed mining activity include sediment with higher heavy metal content being brought to the seabed surface, making it available for consumption by deposit feeders, filter feeders and therefore indirectly to higher trophic levels including fish, marine mammals and birds through food web transfer. In addition, de-ored material with the same metal profile but finer grained being returned to the sea will make these metals more readily available for consumption by benthic organisms (please see Phillips evidence for this hearing for more information).

17. Potential ecological impacts, include heavy metals affecting benthic communities, plankton and fish, which have the potential to cause flow-on effects through the ecosystem on higher level predators including marine mammals and seabirds.

17.1 The information on fish communities in the area relies heavily on modeling, using data from around NZ rather than intensive sampling in the Taranaki area. Insufficient information is available on the ecological linkages between benthic communities, fish communities and marine mammals to be able to determine the indirect, ecological effects of this mining operation.

17.2 Information on the potential benthic impacts relied heavily on an experiment in Wellington Harbour, in an environment very different from Taranaki in terms of its physical and biological characteristics.

17.3 Potential ecological flow-on effects have been identified for other sand mining operations. For example, Diaz et al. (2004) estimated that a sand mining operation off Maryland and Delaware in a 7.7km^2 area removed 300kg wet weight biomass that functions as trophic support for fish. In addition, a transition from crustacean dominated to annelid and bivalve dominated communities, was predicted to reduce the resource value for demersal fish (Diaz et al. 2004). Research on other disturbed benthic environments, has found that as density declines so too does the size of individuals and their spatial distribution. Although not biologically extinct, they may be functionally so. Disturbed areas are generally more homogenous, with a loss of heterogeneity leading to a loss of ecological function (e.g. Thrush and Dayton, 2002). In some cases, opportunistic demersal fish have been observed to change their diet to take advantage of benthic animals disturbed or damaged by human activities, potentially altering community structure (e.g. Kaiser and Spencer, 1994). Bottlenose dolphins have been shown to avoid dredging areas while work was taking place despite already being in a noisy area (Pirotta et al., 2013), indicating that even an already noisy environment does not safeguard against behavioural responses.

17.4 Comparison of mining sites from de Beers offshore diamond mining (off Namibia) with control sites shows that more robust species and opportunistic species tend to dominate marine communities when they start to recover after mining, and that species sensitive to chemical pollution take longer to recover (Savage et al. 2001). These impacts are complex, and depending on the benthic community structure before mining starts the mechanical impacts of mining may be different from the chemical impacts. The appearance of mobile predators, exploiting physically disturbed areas to scavenge on injured or dead fauna has been described for trawling and dredging (e.g. Dayton et al. 1995). The fact that sedimentation and chemical pollution extend beyond the mining site itself has important implications for the design of monitoring studies (Savage et al. 2001).

18. *Cumulative impacts:* The Decision-making Committee must take into account: (a) any effects on the environment or existing interests of allowing the activity, including – (i) cumulative effects. Section 6 of the EEZ Act defines "effect" as including "(c) any past, present or future effect; and (d) any cumulative effect that arises over time or in combination with other effects; and (e) any potential effect of high probability; and (f) any potential effect of low probability that has a high potential impact."

18.1 The conservation status and cumulative impacts for Maui dolphin are of serious concern. There is still considerable overlap between Maui dolphins and fisheries in the area, which is likely to be exacerbated by the mining and the sediment plume resulting from the mining. A detailed assessment of the conservation implications of the proposed mining, including cumulative impacts, will be essential in order to provide the DMC with enough information to make a science-based appraisal of the potential impacts of the proposed mining on marine mammals, in particular for Maui dolphins which are already at an extemely high risk of extinction.

19. *Monitoring:* No detailed monitoring plan has been provided. The data gathered on marine mammals in the area so far are not sufficiently detailed or robust for a before, during, after comparison of the impacts of mining. A considerable amount of additional research will be needed to gather realistic baseline data, as well as data essential to allow the DMC to make a science-based assessment of the likely impacts on marine mammals.

19.1 Data on actual responses of dolphins or other marine mammals to marine mining of the type proposed are required in order to assess the potential impact on marine mammals. Such data should be gathered using a BACI (Before, After, Control, Impact) design. Data on the responses of (non-threatened) dolphin species in other areas where this type of marine mining is used would be required in order to assess the likely impacts of the development proposed. Determining whether dolphins avoid areas with marine mining would take at least three years of "before" and three years of "after" observations, following a rigorous experimental design.

19.2 It is important in designing research and monitoring programmes to consider statistical power, i.e. to ensure that sufficient data are collected to be able to detect environmental effects. In the case of critically endangered species like Maui's dolphin, even very small effects are biologically meaningful but difficult to detect. Sample sizes and the duration of the study need to be much larger to be able to detect biologically meaningful effects in a small population.

19.3 A minimum of three years of research would be required in order to describe biological and physical processes in the area to be mined (e.g. distribution, abundance and movements of marine mammals, fish, elasmobranchs, tidal patterns, currents and sedimentation processes). This is partly because these vary from year to year (e.g. Rayment et al. 2010; Slooten et al. 2006).

19.4 Obtaining data on several key biological parameters, in particular survival rates, reproductive rates and trends in population size, would take at least 10 years of research. The results from this research would provide decision-makers and the public at large with the information needed to support a science-based decision on whether or not the proposed development is sustainable (including data on the actual amount of energy likely to be generated and the likely biological and physical effects).

19.5 Shorter periods of data collection on dolphin populations before mining (e.g. 1-3 years), would result in a monitoring programme with little if any chance of detecting impacts on marine mammals. From a scientific point of view, three years of baseline monitoring is the minimum required to collect baseline data on distribution and abundance of marine mammals and this is also required to provide a realistic chance of detecting effects on other species and on physical oceanographic processes. At least ten years of research is needed to estimate survival and reproductive rates (e.g. Gormley et al. 2012). These baseline data can then be used to carry out a power analysis, to estimate the probability of detecting biologically meaningful effects.

19.6 Marine resources are often managed such that new developments are declined only when harmful effects on other environmental or economic interests can be demonstrated (Thompson et al. 2000). This approach poses particular problems for the conservation of coastal marine mammal populations, partly because there are often several threats affecting the same species. It is often difficult to demonstrate the effects of individual threats and even more challenging to determine the total, cumulative impact of all human activities in the coastal environment on a particular species. Added to that, the challenges inherent in studying marine mammals often result in estimates (of parameters like survival and population size) with relatively low levels of precision and low statistical power to detect environmental impacts. Because marine mammals are long-lived, long-term studies are needed to estimate population parameters and to detect changes in those parameters. During the time taken to detect a change in population size, survival or reproductive rate, it is therefore possible for a population to decline to such low population levels that the risk of extinction (and difficulty in detecting impacts) is substantially increased. Marine mammals are inherently difficult to study. The variances on estimates of population size, and other population parameters such as reproduction and survival are usually high. In response, many countries are adopting precautionary management principles.

20. *In conclusion,* the proposed mining operation involves a number of potentially serious impacts on Maui's dolphins, blue whales and other marine mammals. The potential high risk and lack of data on critical issues (e.g. impacts on marine mammals) require a precautionary approach. A more rigorous environmental impact assessment would be needed to carry out a scientifically robust assessment of the potential impact of this development on marine mammals in the area.

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