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Statement on Noise Conditions
Dr Elisabeth Slooten, University of Otago, 11 April 2014

I am the independent expert on the marine mammals and noise group, and have decided not to sign off on the noise conditions proposed by DOC and TTR for the reasons outlined below. There are too many problems with the noise level (130 dB) the distance specified (500 m) and the potential impacts on marine mammals in the area.

The expert group essentially had to set conditions on the basis of a literature review, because TTR has not provided reliable data on:

- The background noise in the area
- The noise produced by a mining operation such as the one proposed
- Marine mammal presence in the area
- The importance of the area to marine mammals
- The cumulative impacts of mining, in addition to existing impacts

The TTR estimate of background noise (130 dB), the basis for TTR's initial proposal for noise conditions, has been rejected by the expert group. There is no basis in the marine mammal literature for retaining a noise level of 130 dB, and there is no basis for changing the distance in the conditions from 200 m to 500 m without reducing the noise level. The rest of this statement substantiates these points.

Why 130 dB at 500 m?
The joint witness statement included several proposed conditions:

"62. Three different sound levels were considered by the expert group as potential conditions:

a. No single octave band shall exceed 140 dB re 1 μPa Leq at 1km with no one third octave band greater than 130 dB re 1 μPa Leq. [These levels are cumulative levels for the whole TTR activity and it was noted that the specific values were open for discussion];
b. That the cumulative noise not to exceed the ambient level at a distance of 1 km from the source of the activity; and
c. Received sound pressure levels (SPL) should be no higher than 130 dB re 1 μPa RMS SPL at 200 m for any one-third octave bands in the low (10-100Hz), medium (100-10,000 Hz), and high (>10,000 Hz) frequency bands [These levels would need to be measured not estimated]

63. Mr Hegley stated that the values proposed in paragraph 62(a) above were based on the existing ambient values being approximately 130 dB re 1 μPa Leq broadband. This is important as noise can only be measured if it is above ambient. Darran Humpheson noted that if the RMS SPL is 130 dB re 1 μPa at 1 km then it would be much louder (187-189 dB at 1 m) than any of the estimates presented by TTR for their operation and that a noise level of 130 dB re 1 μPa at 200 m would be equivalent to Mr Hegley's estimate of RMS SPL 173 dB re 1 μPa at 1m."

Conditions a) and c) used a 130 dB noise level, based on TTR's background noise estimate of 130 dB. Condition b) references the background, or ambient noise level directly. This condition is more flexible, if TTR's estimate of ambient noise is incorrect (see below).

The statement that "noise can only be measured if it is above ambient" suggests that from 1 km away the noise of the mining operation would be not be audible. This is certainly not the case. The low frequency noise would in fact be detectable many tens of kilometres from the mining operation (i.e. at the shoreline near Hawera and Whanganui, and well offshore). This has serious conservation implications for several marine mammal species in the area, including Maui's dolphins which range at least as far south as Whanganui and offshore to the 100 m depth contour and blue whales which use the area and are particularly sensitive to low frequency noise.

None of the noise conditions discussed so far would prevent noise from the operation reaching many tens of kilometres from the mining operation, or would in any other way limit the amount of noise produced. The conditions simply describe the amount of noise expected from the mining operation.

Draft condition c) in the joint statement used the same noise level (130 dB), but at a much reduced distance (200 m). After the expert conferencing, DOC and TTR have reached a compromise of 500 m. Mr Hegley indicated that for practical purposes it would be easier to measure the noise levels at 500 m, and the compromise noise condition agreed by DOC and TTR is 130 dB at 500 m. This is illogical. If there are good biological grounds for reducing the noise level to 130 dB at 200 m (as argued by DOC) and good practical reasons for measuring noise at 500 m (as argued by TTR), then the noise level should have been reduced accordingly. One could measure noise at 500 m to ensure the noise level at 200 m does not exceed 130 dB.

TTR's background noise estimate of 130 dB was rejected by the expert group as unrealistic. Natural background noise is on the order of 60-70 dB (up to 100 dB in storm conditions). Noise levels of 90 dB are typical of very noisy marine environments (e.g. Boston Harbour). TTR's very high estimate of 130 dB is likely to be due to noise from shipping, the Kupe platform and/or the hydrophone dragging through the water. This invalidates the use of 130 dB as a science-based cut off as a condition for mining noise. It certainly invalidates condition a).

Why continue to use 130 dB after rejecting TTR's estimate of background noise?
It's not clear why the expert group continued to use a noise level of 130 dB for further negotiation about conditions. DOC have argued that this is based on the literature on noise levels causing behavioural changes and physical injuries to marine mammals (in particular Southall et al. 2007). However, as discussed at the hearing the behavioural responses of marine mammals to noise vary considerably between individuals, species, sex, and age classes, and especially, context (Ellison et al. 2011). Southall et al. (2007) and other researchers have therefore avoided providing a specific cut off (such as 130 dB) as a threshold below which impacts can be avoided.

For example, Dr Wursig notes in his Evidence that "Overall, non-pulsed sounds in nature elicited variable reactions (levels 0-6) at exposure levels of 80 to <120, also 120 to <130 dB, and level 6 reactions at 140 to <160 dB." (para 33 of his evidence in chief). In other words, responses up to category 6 (on a scale of 0-9) can be elicited by sounds of 80-120 dB. Melcon et al. (2012) found that blue whales react to noise at around 110-120 dB and as low as 80 dB.

Likewise, orca react strongly (5-7 on Southall's scale) to received noise levels of 90-99 dB and pilot whales show moderate reactions (4-6) at received levels of 80-89 dB (Miller et al. 2012). While the risk of severe behavioural responses is certainly higher above 120-130 dB, the scientific literature indicates that any signal audible to the animal can cause a behavioural response at any severity level between 0 and 7 – with 0 meaning no observable response and 7 indicating extensive or prolonged aggressive behaviour, anti-predator response, strong avoidance of the sound source and separation of mothers and calves. The maximum response on the scale used by Southall et al. (2007) is 9 which includes outright panic, stampede and stranding events.

The following diagram, provided by Mr Humpheson during discussions about conditions, clarifies how the proposed condition of 130 dB compares to the noise expected to be produced by the mining operation

According to Mr Hegley's Executive summary (para 9), the noise created by mining, transporting sand to the FSO and the tug operating would result in 125 dB at 500m. Therefore, the condition of 130 dB at 500 m is actually higher than the expected noise level caused by mining. To put this into perspective, a 3 dB difference is equivalent to doubling the noise level. Therefore, a 5 dB increase from 125 to 130 dB (at low frequencies) is a very substantial increase in the amount of noise received by marine mammals in the area. Mr Humpheson's graph (above) makes it clear that at higher frequencies, the differential between the noise level in the proposed conditions and the noise level expected from a mining operation is very large indeed. The proposed conditions would provide very substantial 'headroom' for TTR, for example in the case of maintenance problems. As briefly discussed at the hearing, blowing an o-ring or throwing a bearing could add up to 60 dB of additional noise, over and above the continuous noise generated by the mining operation.

Would 130 dB at 500 m be a safeguard for marine mammals or for TTR?

The current proposed conditions of 130 dB at 500 m are essentially meaningless in terms of providing protection for marine mammals. There is no obvious biological benefit from setting the conditions at this level. Quite the opposite. These conditions would provide considerable 'protection' for TTR and management agencies in allowing much higher noise levels than are expected to be produced by the proposed mining operation.

The information on noise produced by mining is based on a 1995 report from de Beers mining. This report gives no indication of the high frequency noise produced. The graph above does not include noise above 16 kHz because the sound recording equipment used was unable to record higher frequencies than that. High frequency noise attenuates more quickly, but is more damaging as it contains a higher amount of energy, as shown in recent hearing research on bottlenose dolphins (Finneran & Schlundt 2010).

The most recent research shows that harbour porpoises are surprisingly sensitive not only to the high frequency sound they produce and hear, but also to low frequencies. This result was unexpected. Kastelein et al. (2010) showed that harbour porpoise are sensitive to relatively low frequency noise (500 Hz), at noise levels of about 95 dB, and to noise at 250 Hz at 110 dB. This has serious implications for Maui's dolphin, another high-frequency cetacean, which is already Critically Endangered.

The scientific literature shows that species respond differently to what one would predict based on their audiograms. For example, Pirotta et al. (2012) found a significant change in Blainville's beaked whale behavior with exposure to broadband (but predominantly low frequency) ship noise, at distances of around 5 km. Weir (2008) also found that Atlantic spotted dolphins showed marked responses (overt avoidance) in comparison to sperm and humpback whales, contrary to what one would expect based on audiograms. Dolphins have been shown to detect low-frequency sound, apparently by detecting particle velocity and pressure (Turl 1993). Dolphin skin is highly innervated and sensitive to vibrations (Turl 1993). Dolphins may use their sensitivity to small pressure changes and mechanoreception (in particular of the skin on the head) in the final stages of prey capture.

Likewise, beaked whales appear to be more sensitive to low-frequency sound than would have been expected based on their hearing alone (Ketten 1998). Cook et al. (2006) showed that a Gervais' beaked whale (Mesoplodon europaeus) was quite insensitive at 5 kHz yet this is in the range of frequencies used in mid-range sonar (2.6 and 3.3 kHz or 6.8-8.2 kHz) to which it reacts strongly, even by fatally stranding (U.S. Department of Commerce and U.S. Navy 2001). Thus, audiograms (depictions of sensitivities to frequency) are not a reliably way to determine how susceptible and disturbed a species might be to a particular sound.

Some species react more strongly to new sounds, objects or activities in their environment. For example, Pirotta et al. (2012) note that "our work confirms the particular sensitivity of beaked whale behavior to acoustic exposure." Bain and Williams (2006) note that harbor porpoises are "generally considered more shy" than Dall's porpoises. There are ecological reasons why smaller species, such as Maui's dolphins, might be more sensitive to new sounds, objects or activities in their environment than larger species, as they are more vulnerable to predation. Clearly, frequency is just one, not necessarily the most important, of many features of sound that cetaceans react to.

The biological significance (e.g., consequences for health, survival, or reproduction) of behavioral responses to noise in cetaceans is still uncertain. For practical reasons, often only short-term reactions to noise are studied. Very few studies have addressed how short-term responses translate into long-term impacts. Short-term effects may indicate serious population consequences or they may be insignificant. Conversely, long-term population impacts may occur in the absence of dramatic or even observable short-term reactions, as has been demonstrated in bottlenose dolphins (Bejder 2005) and caribou (Harrington and Veitch 1992). Bejder (2005) found a reduction in bottlenose dolphin calf survival with whale-watching vessels, though short-term behavioral responses seemed very moderate. Harrington and Veitch (1992) found that caribou calf survival was reduced when females were exposed to low-level jet overflights during certain critical periods, despite exhibiting only an apparently minor short-term startle response. Thus, short-term research may be of very limited use in determining biologically significant effects of noise on cetaceans. Long-term studies, however, have more successfully related disturbance reactions to population impacts (Bejder 2005).

Disturbance studies can be similarly difficult to interpret, as they may yield counterintuitive or paradoxical results. For instance, in some species and situations, the weaker the behavioral response, the more serious the impact on the population. Individuals with lower energy reserves or no alternative habitat cannot afford to flee repeatedly from disturbance but are forced to remain and continue feeding, apparently unresponsive to disruption (Gill et al. 2001; Stillman and GossCustard 2002). Yet these individuals are in fact more vulnerable to disturbance. Again, animals do not always react in an observable or obvious manner even if they are seriously impacted. When repeatedly exposed to the same type of noise, animals may habituate or become accustomed to that particular noise over time. Alternatively, animals may show a heightened responsiveness to noise over time, especially if it is associated with a negative experience. Unfortunately, hearing impairment can be misinterpreted to represent habituation, as both would appear to the observer as a decrease in responsiveness to noise. In addition, what appears to be habituation may in fact be the most sensitive individuals permanently vacating the area, while the least sensitive stay (Bejder et al. 2006a). These two scenarios can only be distinguished if all individuals are known and tracked (Bejder et al. 2006b).

Only in-depth, long-term studies are able to detect these kinds of impacts. The brief comments on marine mammal monitoring (baseline and impact data) that have been made available by TTR so far show little if any potential to detect the impacts of mining on marine mammals.

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