UNDERSTANDING THE POTENTIAL IMPACT OF REPEATED EXOSURE TO SEISMIC IMPULSES ON DOLPHIN HEARING

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UNDERSTANDING THE POTENTIAL IMPACT OF REPEATED EXPOSURE TO SEISMIC IMPULSES ON DOLPHIN HEARING

The JIP has funded independent research to help increase understanding of the potential temporary hearing impacts from seismic sound sources on bottlenose dolphins, and differentiate their impact from that of other sound sources such as sonars. Some of the findings from these studies include:

- **Dolphins are relatively insensitive to air gun impulses. This is primarily because air gun impulses have mostly low-frequency energy and contain little energy at the high-frequencies where dolphin hearing is most sensitive.**

- **Behavioural responses to repeated impulses may reduce the levels of sound exposure by the ears, thus reducing the likelihood of temporary threshold shifts.**

Measuring Hearing

The hearing threshold is the sound level below which an ear is unable to detect any sound. The effect of a sound exceeding the normal processing abilities of the inner ear produces what is described as a "Threshold Shift". With Temporary Threshold Shifts (TTS), the hearing threshold returns to prior levels after a period of time. This is only for those sound frequencies at or slightly above the frequency of sound that caused the shift, not the entire hearing spectrum. Sound exposure levels that produce TTS have been used as benchmarks to determine the upper boundaries of safe sound exposure, above which hearing loss across a narrow frequency band may occur.

Background

Bottlenose dolphins (*Tursiops truncatus*) are the most studied group of cetaceans. The results from testing these animals can then be extrapolated to other related species, which cannot be so readily studied in captivity.

Prior to this research, there was no information available on whether multiple exposures to seismic impulses could lead to TTS in bottlenose dolphins, since single exposures had failed to produce TTS at the highest achievable exposure levels[i].

Previous research on multiple exposures had only been conducted using tonal sounds such as sonars, which have different characteristics from seismic sounds. Seismic air sources produce a short duration pressure fluctuation called an 'impulse sound'; the same kind of short pressure oscillations or 'impulses' produced by the crack of nearby thunder and clapping hands. Sonars, human speech and musical instruments, all produce smoother cyclic oscillations of pressure called tonal sounds. These tonal experiments showed that the onset of TTS occurred when bottlenose dolphins were exposed for several seconds or minutes to levels of around 178 decibels (dB) cumulative sound exposure level (SEL), at frequencies in their best range of hearing. Earlier tests with beluga whales (closely related to dolphins), which used tonal sound sources, also produced TTS at 186 dB SEL.

The JIP sought to fill the knowledge gap by funding experiments which measured effects from exposure to multiple impulses from a seismic air source, removing the need to extrapolate from tonal sources.

The Experiment[ii]

Three bottlenose dolphins participated in this study. Tests took place in mesh pens, moored in open water in San Diego Bay at the US Navy Marine Mammal Program facility. The dolphins were exposed to 10 impulses, each of 175-195 dB SEL, separated by 10 second intervals - typical of the intervals during geophysical operations. These pulses were generated by a variable volume seismic sound source (Sercel G-150[iii]). The hearing ability of each dolphin was assessed using traditional behavioural audiometry (the animals' observed reactions to the sound) as well as measurements of auditory evoked potentials (small changes in neurological signals produced when an animal hears a sound). The assumption, based on the data obtained from previous experiments, was that this range of exposure would have been sufficient to generate a hearing threshold shift (e.g. TTS).

A dolphin wears a self-contained acoustic recording device during testing.

Results

Dolphins appear less sensitive to exposure to multiple seismic impulses than to high-frequency tones with the same total energy.

After multiple test sessions, using eight different configurations of source distance, volume, and pressure to gradually increase the source level, the research team was able to produce only a small increase in evoked potential hearing thresholds in one dolphin. No change was observed in the behavioural response hearing thresholds in any of the three dolphins, i.e. the animals were not experiencing TTS as had been expected from previous experiments.

Video of the testing sessions revealed a sideways head turning motion away from the sound source by two of the dolphins after the onset of impulse generation. This suggested to the researchers that the animals might be anticipating the next impulse and reducing the received levels from (i.e. self-mitigating) the loud sounds. Further work is needed to confirm this explanation of the results.

A dolphin turns its head to the side, away from the sound source, just before (i.e., 0.2 seconds) a seismic air gun impulse is generated.

Significance

JIP-sponsored research by Dr. Finneran and his colleagues has shown that exposure to seismic sound sources may not result in TTS at levels extrapolated from experiments using tonal sound sources like sonars. The results also suggest that the animals may possess means of protecting their ears from loud impulsive sounds. This latter finding is in agreement with other research on auditory sensitivity control by echolocating dolphins[iv].

The research team

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ABOUT THE JIP

One of the most extensive environmental industry research programmes bringing together the world's foremost experts across industry, academia and independent research centres.

This fact sheet has been produced by the IOGP E&P Sound and Marine Life Joint Industry Programme (JIP). The JIP was founded in 2005 and supports research to help increase understanding of the potential effect of sound generated by oil and gas exploration and production activity on marine life.

To learn more about the JIP and our research, please visit http://www.soundandmarinelife.org/

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[i] Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A., and Ridgway, S. H. (2002) Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. J. Acoust. Soc. Am. 111: 2929-2940.

[ii] Finneran J.J., Schlundt C.E., Branstetter, B.K., Trickey, J.S., Bowman, V., and Jenkins, K. (2015) Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. J. Acoust. Soc. Am. 137(4):1634-1646.

Finneran, J. J. and Schlundt, C. E. (2013) Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). J. Acoust. Soc. Am. 133:1819-1826.

Kastak, D., Southall, B. L., Schusterman, R. J., and Kastak, C. R. (2005) Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. J. Acoust. Soc. Am. 118: 3154-3163.

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S., and Au, W. W. L. (2009) Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. J. Acoust. Soc. Am. 125:1816-1826

Schlundt, C. E., Finneran, J. J., Carder, D. A., and Ridgway, S. H. (2000) Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. J. Acoust. Soc. Am. 107:3496-3508.

Finneran J.J., Schlundt C.E., Branstetter, B.K., Trickey, J.S., Bowman, V., and Jenkins, K. (2013) Temporary threshold shift (TTS) in odontocetes in response to multiple air gun impulses. Final Report for JIP Project 2.1.1., 51 pp. Available online at http://www.soundandmarinelifejip.org/index.php?doc=docmeta&id=3695

[iii] For more information on the Sercel G-150 please see :
http://www.sercel.com/products/Lists/ProductSpecification/MarineSources_brochure_Sercel.pdf
http://www.soundandmarinelife.org/research-categories/physical-and-physiological-effects-and-hearing/tts-in-odontocetes-in-response-to-multiple-airgun-impulses.aspx

[iv] Nachtigall, P.E., Supin, A.Y. (2014) Conditioned hearing sensitivity reduction in a bottlenose dolphin (*Tursiops truncatus*). J Exp Biol 2014 217:2806-2813.