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Free field hearing tests on wild Atlantic walruses (*Odobenus rosmarus rosmarus*) in air

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Summary

A pilot free field hearing study was carried out on Atlantic Walruses which were hauled out at a beach on Svalbard, Norway. Five animals were exposed to two types of acoustic signals between 250 Hz and 4 kHz. The animals responded to signals with sound pressure levels of 10–20 dB above ambient noise levels, and it may be concluded that the hearing responses of Walruses do not seem much different from those of humans under similar environmental conditions. The experiment shows that it is possible to carry out rough audiometric tests in the field.

Key words: Walrus, *Odobenus*, acoustics, hearing, audiogram, ambient noise.

Introduction

For social interactions, animals depend on cues detected with their sensory systems. Walruses are very social and vociferous animals (Miller, 1985), and therefore acoustic signalling is probably an important factor in their ecology. Nothing is known about the hearing sensitivity of Walruses. For conservation purposes, it would be useful to know the distance at which Walruses may detect a particular man-made (usually low frequency) noise. Man-made airborne and underwater noise audible to Walruses may change their behaviour, and thus eventually influence their population dynamics. The capability of the Walrus to detect a certain sound, however, depends not only on its hearing sensitivity, but also on the masking effects of the ambient noise emanating from natural sources, such as wind, waves, ice, etc. The higher the ambient noise level, the greater the masking effect and the less sensitive the Walrus is to man-made noise. The aim of this study is to determine the in-air low-frequency hearing sensitivity of Walruses in the wild, measured in their natural surroundings with natural ambient noise.

Materials and Methods

Location and conditions

Researchers sailed on the vessel *Polarsyssel* along the coast of the Svalbard archipelago, Norway, until they saw a group of about 30 male Atlantic Walruses hauled out on a natural 25 m wide gravel spit in the Forlandsundet (Sarstangen: 78°45′ North latitude, 11°30′ East longitude). A team went ashore in a small boat, 200 m from the herd and calmly approached the Walruses on foot. In order not to disturb the animals the last 30 m was crawled.

The ambient airborne sound pressure level near the animals was determined using a dBA-filter as well as 8 full-octave bandfilters in the range between 63 Hz and 8 kHz. A Philips PM 6400 sound level meter with octave band filter PM 6410 (Meter response: R.M.S./slow) was used for these measurements. These ambient noise measurements were taken immediately after the hearing tests were conducted. The ambient noise fluctuated around 45+or−3dB(A) SPL and was mainly caused by small (10 cm) waves on the beach (Table 1). No ocean swell was detectable, and it was sunny, 1 Beaufort windforce, air temperature was 14°C, relative humidity was 55%, and air pressure 1012 mbar.

One researcher crawled to within 2 m of a Walrus' head to conduct audiometric tests. An audiometric technique was used which was developed to test the hearing system of human babies by watching their reactions to calibrated sound signals from a loudspeaker. The Walruses on Svalbard were selected for this study, because in contrast to Walruses in most other parts of the world, Walruses on Svalbard can be approached close enough to position the loudspeaker, when hauled out on land.

Table 1. The averaged ambient sound pressure level near the herd of 30 Atlantic walruses hauled out on a gravel beach on Sarstangen, Svalbard (Level in dB re 20 µPa, filter bandwidth 1/1-octaves). The ambient noise fluctuated + or − 3 dB around these averages.

Hz	63	125	250	500	1 k	2 k	4 k	8 k	dBA	Lin
dB	35	35	40	45	45	45	45	35	45	50

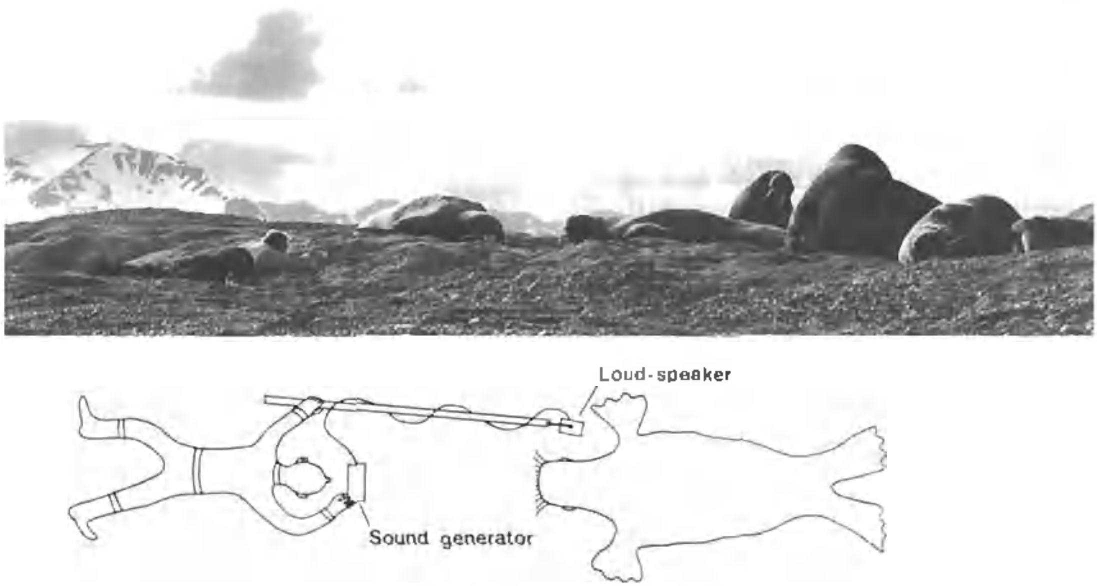


Figure 1. Approach towards a herd of male Atlantic Walruses hauled out on a beach at Sarstangen, Svalbard archipelago, Norway for free field hearing measurements (Photo: David Griffiths). The drawing shows an overview of the situation during data collection. The generator is placed so that the animal could not see the button which elicited a sound signal being pushed (Drawing: Ron Kastelein).

Sound signals used in audiometric tests

A custom-built portable sound generator was used for the experiment which could produce 2 types of calibrated sound signals:

a) Filtered band noise. Center frequencies around: 250, 500, 1000, 2000 and 4000 Hz, slope: 24 dB/octave, bandwidth: 1/1 octave.

b) Modulated tones. Center frequencies: 500, 1000, 2000 and 4000 Hz. The center frequencies were modulated according to the 'Frequency shift keying' method. Switching frequency: 12 Hz by square wave, modulation depth: + or − 4%, creating sweeps in the following discrete frequency ranges: 480–520, 960–1040, 1920–2080, 3840–4160 Hz. Because of the small modulation depth, the sound signal had a 'tonal' character.

These signals were chosen because in non-cooperative humans (such as children), these stimuli have a higher arousal property than pure sinus-shaped signals. There was no danger that the animal reacted to frequencies other than the emitted test frequencies, because the sound level of the harmonics was very low.

Experimental procedure

The sound pressure level could be varied in 9 calibrated 10 dB steps by 3 amplitude settings (30 dB difference between each) and by varying the distance between the loudspeaker and the Walrus' meatal orifice in 3 stages (10, 33 and 100 cm), giving 10 dB attenuation steps. The loudspeaker was positioned in a horizontal plane with the head,

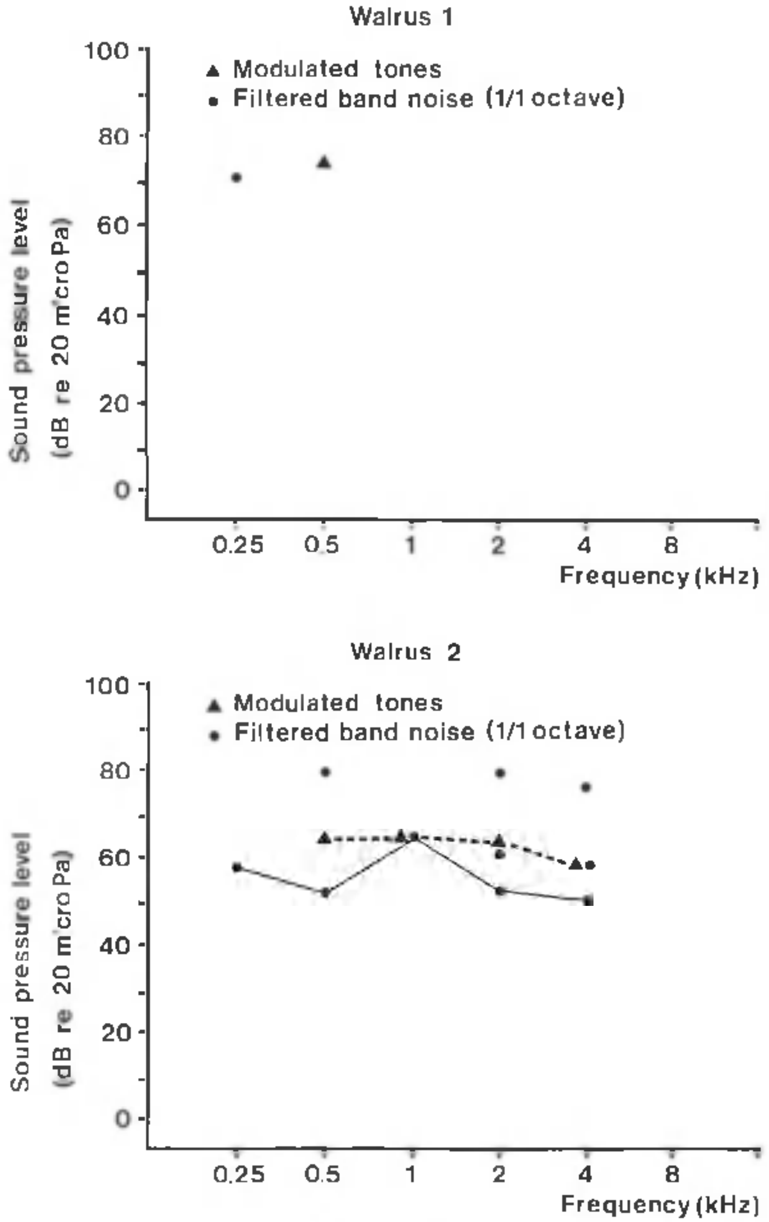
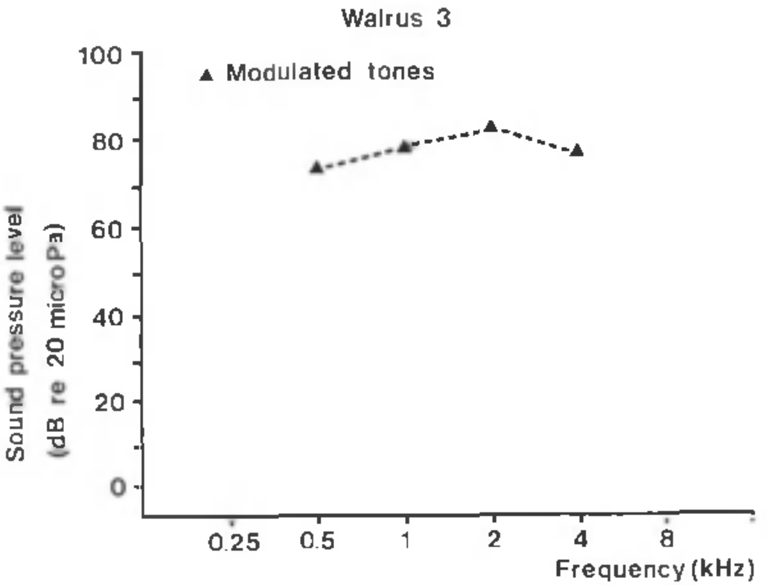


Figure 2a and b.

Figure 2. The hearing sensitivity data of 5 Atlantic Walruses hauled out on Svalbard for filtered band noise and modulated tone signals between 250 Hz and 4 kHz. The lowest amplitudes that the animal responded to are connected by lines.

at an angle of about 100 degrees to the sagittal plane of the head measured from the rostrum. The loudspeaker was always placed next to the right ear of a Walrus. For safety purposes and in order not to elicit responses to non-acoustic stimuli, which might have been mistaken as reactions to the sounds from the generator, the loudspeaker was on a 3 m long pole (Fig. 1). The generator was positioned in such a way that the animal could not obtain visual cues from its operation.

The sound pressure level of the first signal was chosen to be below the expected sensitivity



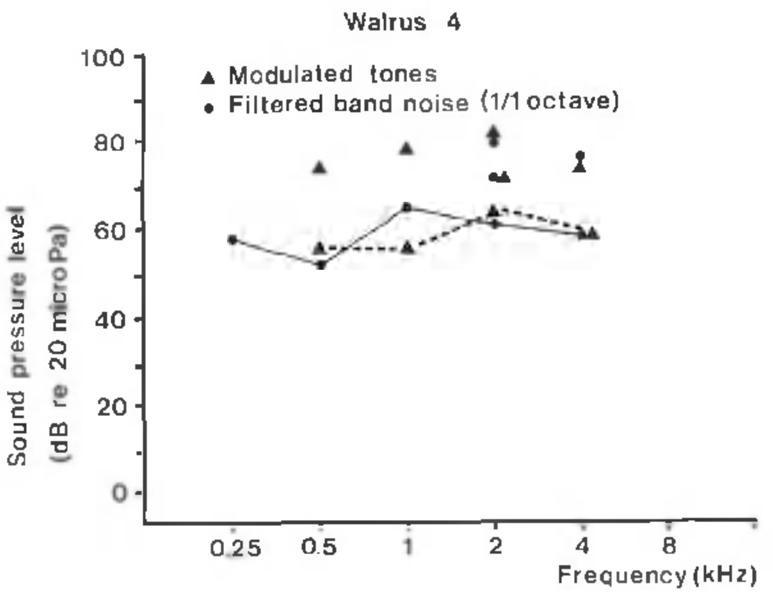


Figure 2c and d.

threshold (based on laboratory measurements by Kastelein *et al.*, in prep.). Each sound was produced for about 3 seconds. If after 2 attempts, the animal did not show a response within the period the sound was produced, or immediately afterwards, the sound pressure level was increased by 10 dB. This was done either by changing the amplitude setting on the apparatus or be decreasing the distance between the sound source and the animal's meatal orifice by a factor of 3. This procedure was continued until the animal responded to the sound. If the animal responded to 2 identical signals with an inter signal time delay of about 10 seconds, this level was considered as the hearing response under these environmental circumstances. The next step depended on the reaction of the animal: if the Walrus relaxed after the reaction to the sound, another frequency was tested on the same animal;

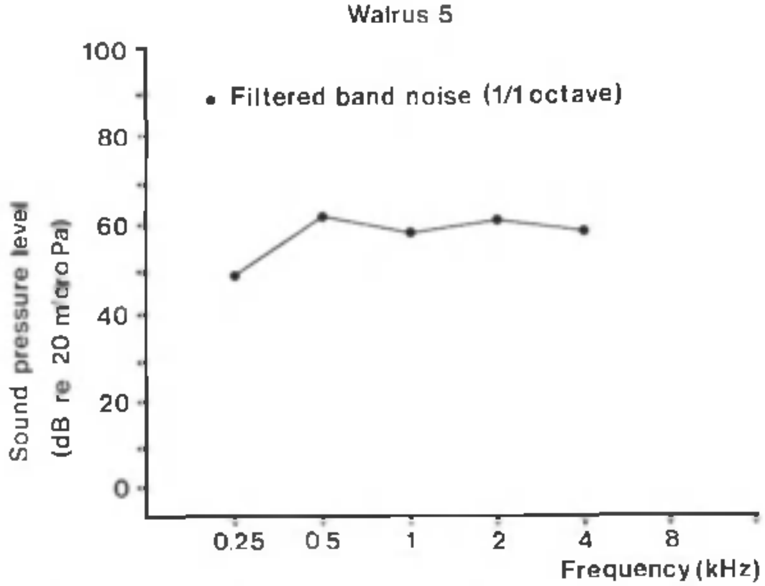


Figure 2. The hearing sensitivity data of 5 Atlantic Walruses hauled out on Svalbard for filtered band noise and modulated tone signals between 250 Hz and 4 kHz. The lowest amplitudes that the animal responded to are connected by lines.

if the animal remained very alert, and kept scanning its surroundings, another animal was selected.

The designed measuring technique could not always be followed; because the loudspeaker's movements sometimes had to be limited in order not to disturb the animal, signals of a higher level (created by changing the amplitude setting on the sound generator) than the lowest level the animal responded to were also offered, and the usually very strong reaction of the animal was recorded.

The hearing data and ambient noise levels were collected in one session on July 14, 1992 between 16.00 and 18.00 hrs.

Results

It was possible to safely approach and test the hearing of 5 male Walruses, lying along the perimeter of the herd. All animals were dry, which meant that they had been hauled out for some time. The animals tested were within 2 m of other Walruses. They were awake, but often appeared drowsy. After sometimes lifting their heads for 10 to 30 seconds, they slowly lowered them again towards the substrate. When tested, the heads of the study animals were either vertical (right-side up), or horizontal, but never upside down, a posture often seen in sleeping Walruses.

The most frequently seen response to the sound signals was opening of the eyelids followed by rolling of the eyes (perhaps indicating that the animal was searching for the sound source). If the sound was loud (i.e. 10 dB or more above the lowest amplitude the animal reacted to), the animal would raise its head, and look at the loudspeaker. If the sound signal was produced at the level the animal first reacted to, it had to be produced for more than 1 sec. to elicit a response. Only after producing the signal for 2 to 3 seconds was a reaction seen. The animals soon habituated to the sounds, and usually did not react when the same sound was produced the third time in succession within 20 seconds.

The results from the 5 Walruses are shown in Fig. 2. It was impossible to derive a complete data set from all 5 animals. Animal 1 (tusk length: 50 cm) was restless and after 2 test signals attacked the loudspeaker. Animal 2 (tusk length: 30 cm) was at ease and allowed all frequencies for both types of sound signals to be tested. He seemed interested in the loudspeaker, and held his head close to it. He even drove Walrus 3 (tusk length: 20 cm) away from the loudspeaker when that animal was being tested. This resulted in a partial test of Walrus 3. Animal 4 (tusk length: 30 cm) was at ease, and allowed all frequencies of both sound types to be tested. After the filtered band noise signals were tested, animal 5 (tusk length: 65 cm) became restless, and moved into the herd, out of reach of the loudspeaker. The young animals in the herd were curious, and sometimes approached and threatened the researcher and/or the loudspeaker.

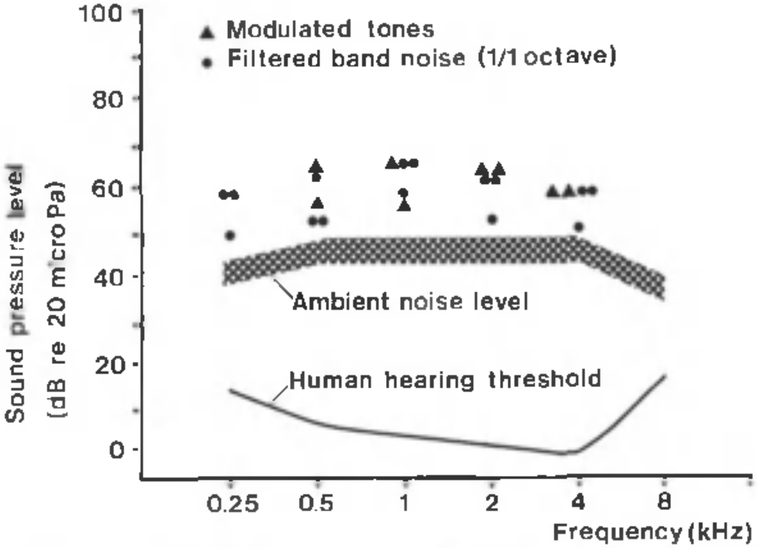


Figure 3. The lowest levels of filtered band noise and modulated tone signals Walruses 2, 4 and 5 responded to, the 1/1-octave averaged ambient noise level + and − 3 dB (mainly caused by wind and the surf), and an audiogram derived from free field measurements on good hearing humans under laboratory conditions (ISO/CD 226-1, N838, 1992).

Discussion and conclusions

The lowest levels the animals reacted to for the 1/1-octave filtered noise band signals and the modulated tones are rather similar (see Walrus 2, 4 and 5 in Fig. 2). Therefore these data are combined in Fig. 3. The hearing sensitivity of Walrus 3 seems worse than that of Walruses 2, 4 and 5, so its data are omitted in Fig. 3. The pooled data in Figure 3 indicate that the arousal character of noise band signals and modulated tones is similar in Walruses and humans.

It is remarkable that the response threshold for the 1/1-octave band noise signals are at the same level as the response threshold for the modulated tone signals, although the masking effect of the ambient noise (similar to white noise) is less for modulated tone signals than for filtered band noise signals.

The sound pressure levels of the produced sound signals to which the animals responded were 10 to 20 dB above the ambient (1/1-octave) noise level (Fig. 3). A more precise hearing measurement could not be determined under the non-laboratory circumstances of the present study. In humans one might also expect responses at signals only approximately 15 dB above the averaged ambient noise level.

The present pilot study shows that it is possible to do rough audiometric measurements in the field, provided environmental conditions (i.e. weather, waves and biological sounds) are not extreme.

Because the animals did not like the loudspeaker being moved within about 40 cm of their heads (unless they themselves moved their heads closer to it), future studies should be done with a loudspeaker which is calibrated in such a way that the distance between the loudspeaker and the meatal orifice could always be 50 cm, and that the sound level can be varied by amplitude settings on the sound generator (steps of 10 dB steps or less).

Acknowledgements

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