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NOTE

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# Percussive underwater signaling in wild gray seals

David P. Hocking[1,2] | Ben Burville[3] | William M. G. Parker[1,2] | Alistair R. Evans[1,2] | Travis Park[4,5] | Felix G. Marx[1,2,6]

[1]School of Biological Sciences, Monash University, Clayton, Victoria, Australia

[2]Geosciences, Museums Victoria, Melbourne, Victoria, Australia

[3]School of Natural and Environmental Sciences, Newcastle University, Newcastle, United Kingdom

[4]Department of Life Sciences, Natural History Museum, London, United Kingdom

[5]Department of Earth Sciences, University of Oxford, Oxford, United Kingdom

[6]Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand

**Correspondence**

David P. Hocking, School of Biological Sciences, Monash University, 25 Rainforest Walk, Clayton, Victoria 3800, Australia.
Email: david@dphocking.com

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Sound plays a crucial role in marine mammal ecology, and has led numerous species to evolve a diverse vocal repertoire (Dudzinski & Gregg, 2017; Winn & Schneider, 1977). Nonvocal auditory behaviors like flipper slaps and breaches are also important, but more limited in scope and thought to occur mostly at the surface of the water (Würsig & Whitehead, 2017). Here, we report a novel type of percussive signaling in wild gray seals (*Halichoerus grypus*), which demonstrates that nonvocal auditory behaviors may also be produced entirely underwater.

Our observations are based on video footage of a male gray seal repeatedly clapping together its paw-like forelimbs to produce a sharp, snap-like sound (Figure 1). The video was taken near the Farne Islands (northeast England, UK; 55°38′35.2″N, 1°36′16.9″W) during the 2017 breeding season (17 October). It was recorded by one of the authors (B.B.) using a GoPro Hero 4 Black camera (video: 1920 × 1080 pixels, data rate 30 Mb/s, 25 frames per second; audio: advanced audio coding format, bit rate 127 kbps, sample rate 48 kHz) while SCUBA diving 2.5–3 m behind the seal.

The clapping movement lasts <1 s and may be a ritualized version of a swimming stroke (Sullivan, 1981). From their resting position lateral to the chest, the forelimbs are forcefully adducted and somewhat retracted, until the palms meet ventral to the chest (Figure 1). This produces a piercing clap lasting <0.1 s and reaching maximum frequencies >10 kHz (Figure 2a). The forelimbs then separate, rotate outwards, and continue to retract until the palms approach or hit the abdomen, before finally returning to their original position (Figure 1).

Clap-like sounds have previously been reported in hydrophone-based studies of breeding gray seals from both sides of the Atlantic (Figure 2b), but were interpreted as knock-like (or "type 8") vocalizations resembling those of walruses (Asselin et al., 1993; McCulloch, 2000). The latter, however, emit hundreds of knocks in short succession, whereas gray seal knocks only occur in groups of 1–5 (Asselin et al., 1993; McCulloch, 2000). Conversely, the

  

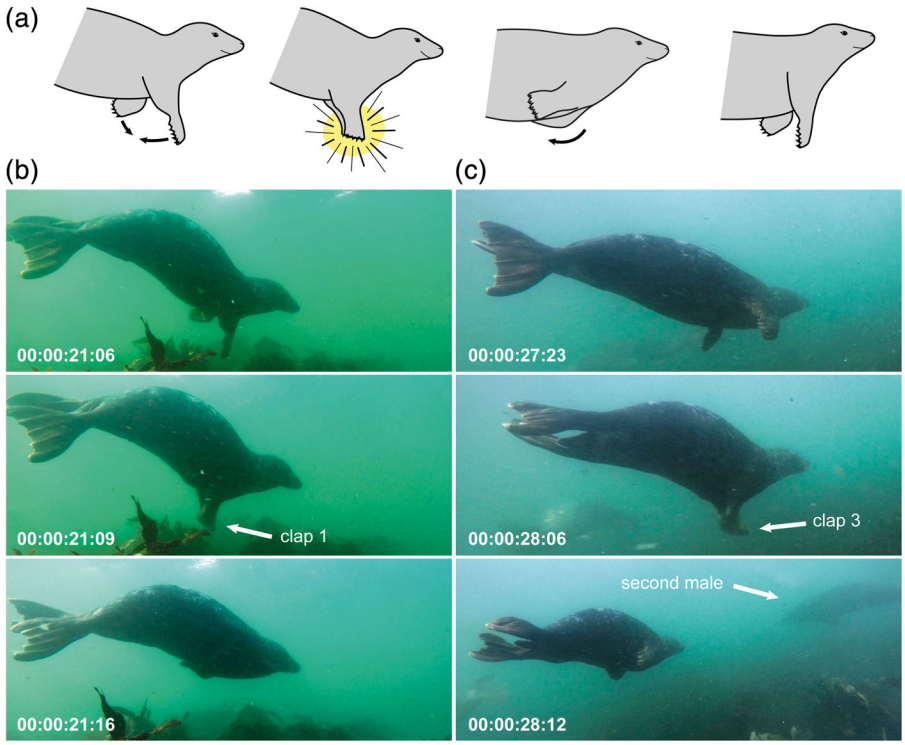


**FIGURE 1** Wild gray seals use forelimb claps as an underwater percussive signal. (a) The clap is produced via forceful adduction of the paw-like forelimbs below the chest. Following contact, the forelimbs separate, move posteriorly, and then return to their resting position. (b–c) Video series showing an adult male gray seal performing two forelimb claps (time code in hours:minutes:seconds:frames; frame rate is 25 frames/second).

purported knocks match our recordings in their small number, short duration, and high maximum frequency, and therefore may represent misidentified nonvocal claps. If correct, this interpretation implies that gray seals employ underwater percussive signaling across their range, but additional observations are necessary to confirm this.

Claps stand out from lower-frequency vocal signals because of their greater frequency range (Ravignani et al., 2016), and match a local optimum in phocid (including gray seal) hearing sensitivity around 10–30 kHz (Hemilä et al., 2006; Kastak & Schusterman, 1999; Ridgway & Joyce, 1975; Terhune, 1988; Terhune & Ronald, 1975). Interactions between individual seals suggest that they form part of social and/or agonistic interactions. In our video (Supplementary Information) a male and a female initially swim side by side in front of the camera, with the female uttering a guttural "rupe" (sensu Asselin et al., 1993; McCulloch, 2000) (Figure 2c). The female then leaves the frame, while the male turns and starts to swim some distance ahead of the observer. The male claps for the first time at 21 s, in tandem with a reply clap by another individual outside the field of view. At 26 s and 28 s, two further claps by our focal individual appear to be aimed at a second male crossing its path from the right. At 29 s there is a further reply clap likely produced by the "intruder," but the water is too turbid to identify the source unambiguously. At 34 s, a female enters the field of view, eliciting two claps by our male at 35 s. He then starts to pursue the female and nearly bites her on the hind limb, before seemingly chasing her away with a further clap at 40 s. After breaking off the pursuit, our male performs a final clap at 43 s, and at 48 s finishes with a guttural "rup" (sensu Asselin et al., 1993; McCulloch, 2000; Figure 2d).

Similar clapping behavior has been observed on five different occasions (and was heard >20 times) over a 20-year period by one of the authors (B.B.), but could not be captured on film because of its rapid nature and usually

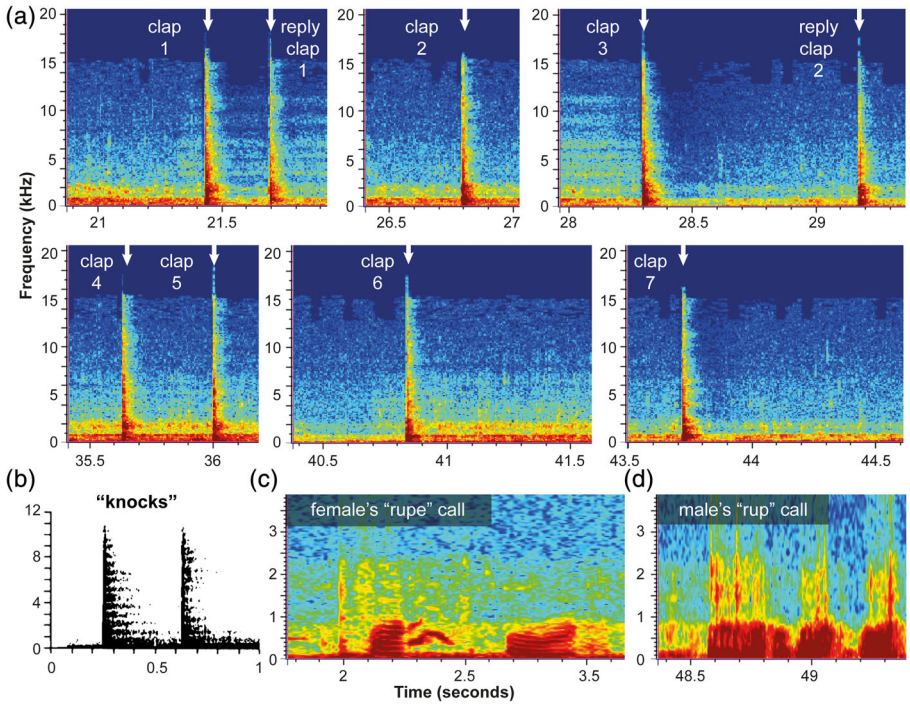


**FIGURE 2** Claps resemble the purported gray seal "knocking" vocalization. (a) Frequency spectrograms of the claps performed by our focal male gray seal, and reply claps by other individuals in the vicinity. (b) Frequency spectrogram of the previously described "knock-like" vocalization (Asselin et al., 1993), which in fact appears to be a percussive clap. (c) Guttural "rupe" vocalization (sensu McCulloch, 2000, Asselin et al., 1993) produced by the female at the start of the video. (d) Guttural "rup" vocalization (sensu McCulloch, 2000, Asselin et al., 1993) produced by the focal male at the end of the video. Spectrograms were visualized using RavenLite 2.0 (Center for Conservation Bioacoustics, 2016). The full video is available as Supplementary Information.

sudden onset. As far as we can tell from these anecdotal observations, claps (1) are only performed by males, (2) rarely number more than one or two, and (3) tend to be aimed at other seals in the vicinity. We cannot exclude the possibility that clapping may also have been directed at the diver; however, its constant association with the presence of other seals and frequent occurrence even when the diver is out of sight make this interpretation unlikely.

Overall, we tentatively interpret clapping as a male behavior used to ward off potential competitors and/or advertise fitness to females. Similar functions have been ascribed to surface-bound percussive behaviors in other marine mammals (Dudzinski & Gregg, 2017; Würsig & Whitehead, 2017). In male harbor seals (*Phoca vitulina*), for example, flipper slapping appears to play a role in lekking and/or territorial defense (Boness et al., 2006; Hayes et al., 2004; Sullivan, 1981). Similarly, humpback whales (*Megaptera novaeangliae*) use pectoral flipper slaps as an aggressive, competitive, or possibly advertising signal (Dunlop et al., 2008; Félix, 2004). Like gray seal claps, these surface behaviors produce brief, explosive sounds with maximum frequencies >10 kHz (Thompson et al., 1986; Wahlberg et al., 2002), albeit with the crucial difference that they can be heard (and thus be effective) both above and below the surface of the water (Perry, 1993).

There are insufficient data to determine whether clapping occurs in other marine mammals. Differences in forelimb anatomy and drag arising from relatively larger flipper surface areas may preclude such behavior in otariids and cetaceans, but presumably not in other dexterous phocids. Even if claps were unique to gray seals, the broadband signal they produce appears surprisingly common among marine mammals, from pectoral flipper

slaps in harbor seals and humpbacks, to knock-like vocalizations in walruses, "gunshot" sounds in right whales, and lobtailing behavior across a variety of cetaceans (Dunlop et al., 2008; Hayes et al., 2004; Parks et al., 2005; Stirling et al., 1987; Würsig & Whitehead, 2017). This wide distribution may suggest a convergent need for certain signals to carry far and/or stand out from species-specific vocalizations. Future studies might benefit from a systematic comparison of the frequency ranges and loudness of marine mammal percussive sounds, and the contexts in which they are produced.

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## ORCID

*David P. Hocking* https://orcid.org/0000-0001-6848-1208
*William M. G. Parker* https://orcid.org/0000-0001-9289-5646
*Alistair R. Evans* https://orcid.org/0000-0002-4078-4693
*Travis Park* https://orcid.org/0000-0002-9492-8859
*Felix G. Marx* https://orcid.org/0000-0002-1029-4001

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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